MARCH 5, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

LINEAR ENERGY ABSORBERS

Contents, Page 3

VARIABLE-PRESSURE SHOCK ABSORBERS

AIR CYLINDERS • VOLUTE SPRINGS

CONICAL-DISC SPRINGS • RING SPRINGS

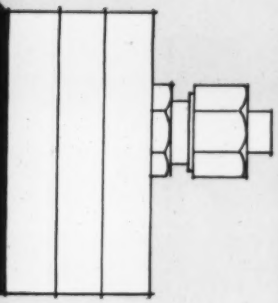
"SINGLE - SHOT" SHOCK ABSORBERS

HELICAL SPRINGS • LIQUID SPRINGS

CONSTANT-PRESSURE SHOCK ABSORBERS

FARNSWORTH

off-the-shelf pumps just right for your requirements



Whatever you want in a pump – for hydraulics, for flow or process control, there is likely to be an Eastern ready-made unit . . . made-to-order for your needs.

CAN YOU USE THESE PUMP FEATURES:

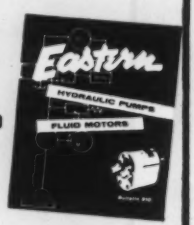
- ☐ corrosion resistant construction for chemical solutions?
- ☐ ability to handle organic and inorganic fluids at various temperatures with flows up to 70 GPM, pressures to 65 psig?
- ☐ available with open, enclosed or explosion proof motors?
- ☐ compact lightweight units with or without motor?
- ☐ high efficiencies in handling hydraulic oil, fuel and lubricants at high pressures?
- ☐ flow rates from 0.1 to 9.8 GPM, pressures from 0 to 1500 PSI?
- ☐ self-priming operation with non-lubricating liquids?
- ☐ high pressure outputs with small, low power units... and no contamination of fluid?
- ☐ flow rates from ½ GPM to 5½ GPM, pressures from 30 to 200 PSI?

An EASTERN CENTRIFUGAL PUMP MIGHT BE JUST RIGHT FOR YOU!

Write for Bulletin 120.

Look into EASTERN HYDRAULIC PUMPS!

Write for Bulletin 810



Get to know more about EASTERN POSITIVE DISPLACEMENT PUMPS!

Write for Bulletin 220.

These useful brochures contain full specifications on the complete line in each category, including performance data and tables. They will be sent to you at no obligation whatever. Write Department R.

EASTERN INDUSTRIES PUMP DIVISION

EASTERN INDUSTRIES, INC.

100 SKIFF STREET, HAMDEN 14, CONN.

Circle 401 on Page 19

SWEET KISSES FOR SWEET CHARITY
PRESS BOTH SIDE BUTTONS AT THE SAME TIME TO RAISE SEPARATING SCREEN
KISSES $1.00
KISSES $1.00

What? Air Polices the Hands Off Policy!

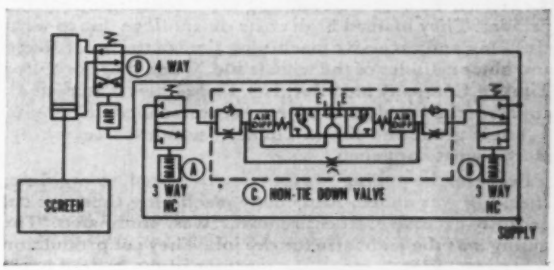
We are not serious, but—

The boys might forget that a kiss doesn't involve the hands but this circuit doesn't. The screen takes care of this. When both his hands depress the actuator buttons, they start the sequence to lift the screen, but "sneaking" one hand off calls for the screen to again guard Miss "Belle-of-the-Bazaar." Our society is pretty romantic so we doubt if this "automatic bolster" will ever become popular. But as a safety feature on presses, brakes and shears the Ross non-tie-down valve, designed to keep both the operator's hands occupied, should become popular.

If you are interested in "two-hand safety" you are interested in a Ross non-tie-down valve.

If the operator follows instructions, then two three-way valves, either in series or in parallel, can protect his hands to a degree; but the *operator* who sets his mind to it, can beat either of these hook-ups and keep one hand free. This valve is designed to avoid one hand operation. In the Ross non-tie-down circuit, both three-way button valves are depressed at once to initiate an action and both released before another action can be initiated.

The Ross non-tie-down valve is just one of the many designed by Ross to assist in creating safer press circuits. Call your nearby Ross engineer or write for full details.



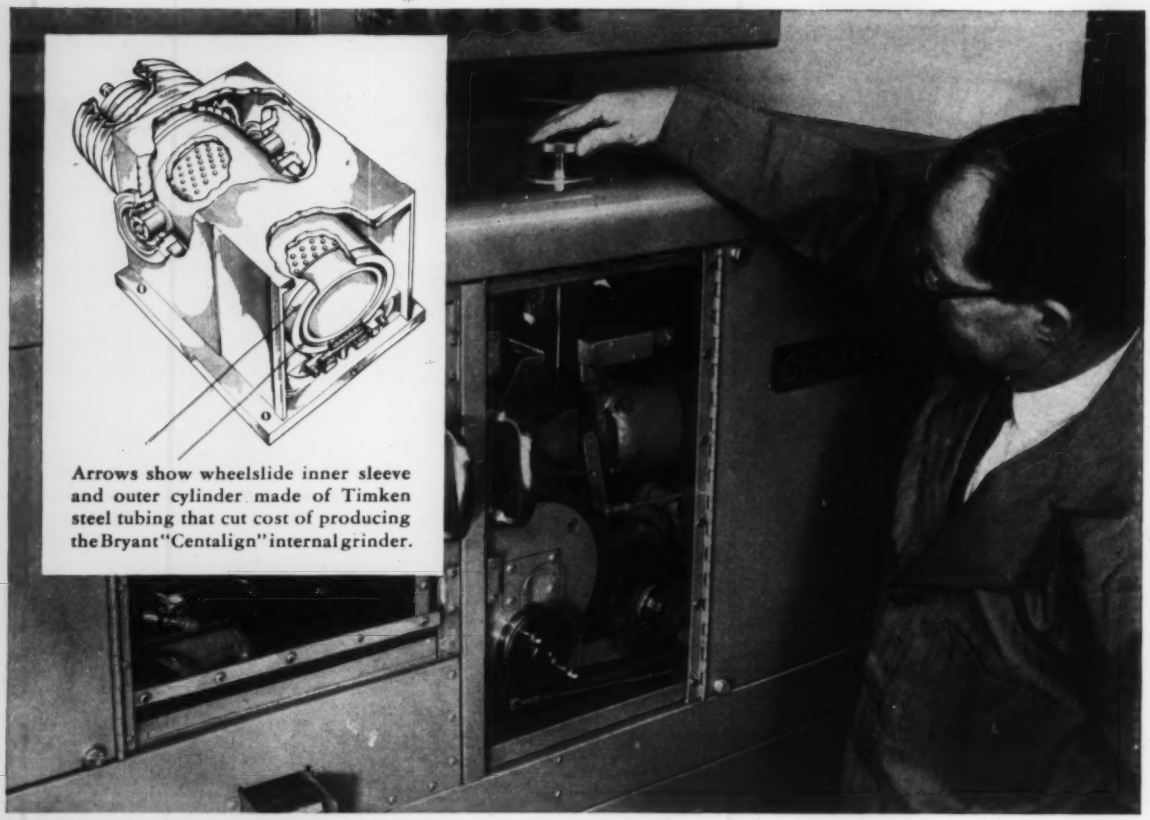
SEQUENCE OF OPERATIONS

- Operating valves "A" and "B" simultaneously permits air to flow through the valve "C", shifting valve "D". Valve "D" operates cylinder raising screen.
- De-actuating valves "A" and "B" simultaneously de-actuates valves "C" and "D". Cylinder retracts and valve "C" re-sets itself for another cycle.
- Operating either valve "A" or "B" independently will *not* cause valve "C" to pass actuating air to valve "D".
- De-actuating either valve "A" or "B" independently, causes pilot air to valve "D" to be exhausted through valve "C". After that occurs both valves "A" and "B" must be released to re-set valve "C" before it will pass air to valve "D" again.

ROSS OPERATING VALVE CO.

109 E. Golden Gate Ave. • Detroit 3, Michigan

Circle 404 on Page 19



Arrows show wheelslide inner sleeve and outer cylinder made of Timken steel tubing that cut cost of producing the Bryant "Centalign" internal grinder.

BRYANT CHUCKING GRINDER CO.

Saves 45% with switch to TIMKEN® steel tubing

ENGINEERS at Bryant Chucking Grinder Co. wanted to reduce the cost of producing this "Centalign" internal grinder. They blamed high costs on spoilage due to weld checking and excessive machining time of the inner sleeve and outer cylinder of the wheelslide. When they consulted Timken Company metallurgists, these experts studied all angles of the problem. And they recommended a change to a certain grade and size of Timken® seamless steel tubing. Here's what happened.

Because the tubing was perfectly suited to welding, checking was ended. And costly machining time was cut because excessive stock removal was eliminated. The tubing was the right size for the job. They cut production costs 45%! What's more, the tubing had the desired hardness and grinding properties, responded uniformly to heat treatment.

Timken seamless steel tubing gives better quality finished products because of the way we make it. We forge a solid round over a mandrel, thoroughly working the metal inside and out. This rotary piercing operation gives the tubing its fine forged quality and uniform spiral grain flow for extra strength. Careful control keeps this quality uniform from tube to tube, heat to heat, bar to bar.

To help cut costs on your hollow parts jobs, let our engineers recommend the tube size most economical for you. It's guaranteed to clean up to your finished dimensions. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of tapered roller bearings, fine alloy steels and removable rock bits.

Timken alloy steel and seamless tubing is available from warehouse stock in 44 cities in the United States. Call your local Timken Company sales office for the name of your nearest Timken steel distributor.

TIMKEN® *Fine Alloy* STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Circle 405 on Page 19

Front Cover: A heavy impact can be "cushioned" by many types of energy-absorption devices. As pointed out by Lloyd Polentz in his article on Page 116, some types return the energy to the system. Others, as shown by cover artist George Farnsworth, absorb the shock load.

March 5, 1959

Design For Survival 22

NEWS REPORT—Latest developments in escape systems for safe, emergency bailouts from aircraft operating at high speeds or low altitudes.

The Future of An Engineer 96

RICHARD W. WALLEN—A psychologist maps the road to advancement for engineers: What the opportunities are, what it takes, what it "costs."

Deep-Hole Drilling 103

JOHN C. DIXON—A practical design guide to the process, its application possibilities and limitations, and design requirements and practices.

Hydraulic Switching Circuits 108

HAROLD R. RONAN Jr.—*Part 2: Spool-Valve Equivalents and Special Circuit Elements*—Using logic functions to simplify component selection in complex hydraulic circuits.

Linear Energy Absorbers 116

LLOYD M. POLENTZ—How to slow or stop moving objects with different devices that either store or dissipate the energy of impact.

Thermal Stresses in Design 125

S. S. MANSON—*Part 9: Elastic-Stress Solutions*—Two approximate methods for simplified analysis of complex relationships in thermoelastic equations.

Size-and-Location Tolerances 131

REG STANLEY—How to set up functional tolerance relationships based upon the standardized concept of maximum-material condition.

Preferred Pinion Sizes 133

GUSTAV A. LARSON—*Data Sheet*—Tables of dimensions for fine-pitch pinions with diameters enlarged to avoid undercutting or interference.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

March 5, 1959

Volume 31 — No. 5

Head Shrinker at Work 95

BENJAMIN L. HUMMEL—*Editorial*

Engineering News 6

Wheelless Levacar rides on air cushion—switching system doubles undersea telephone-cable capacity—continuous process brazes honeycomb panels economically—government becomes a more popular employer—alloy has advantages of cast steel and malleable iron—nuclear aircraft delay is decried by Joint Committee on Atomic Energy—AIEE president says small industry needs co-op research.

Scanning the Field for Ideas 101

Peel-back membrane seal between piston and cylinder—counter-rotating nuts in power-screw drive—rubberized drive shaft.

Design in Action 122

Dual-range transmission permits "on-the-fly" power shifting—flat springs double as elevator cables and "motors."

Tips and Techniques

Opposite-hand lettering. 107
Evaluating exponentials. 107
Pencil pointer 121
Cube roots 121
Squaring numbers 121

Design Abstracts 137

New Parts and Materials 146

Engineering Department Equipment 167

Engineer's Library 170

Noteworthy Patents 174

Meetings and Expositions 35

Helpful Literature 140

Subject Index 17
Reader Service Cards . . 19
Advertising Index 187
Business Staff 187

IN THE NEXT ISSUE: Transistorized car ignition . . . patent utility . . . mechanical analog computers . . . cyclic three-gear drives . . . actuating limit switches . . . thin-walled circular beams

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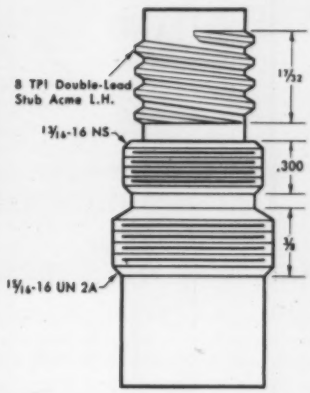
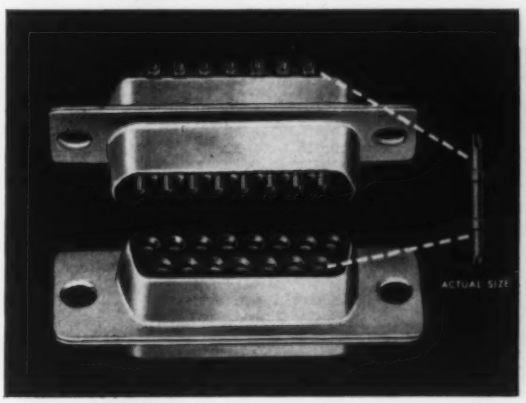
COST CUTTING on tough jobs—like rolling a double-lead Stub Acme thread—may be easier than you think. Olson Mfg. Co. needed only a minor adjustment in a standard Anaconda rod

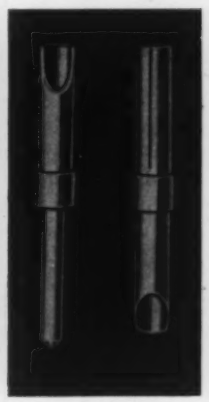


Rolling three threads *(drawing, right)* in two positions on a 6-spindle automatic meant cost savings for Olson Mfg. Co., Worcester, Mass. The Acme thread, however, posed problems. American Brass specialists suggested minor modification of standard Anaconda Free-Cutting Brass Rod to provide the extra ductility needed. The idea worked and the resulting valve spindle is shown above, about 1½ times actual size.

—or maybe you need a different alloy rod. The tiny connectors, right, have to be machined from .078" rod, requiring many precision form-cutting, drilling, slotting operations. So machinability is a vital property of the rod used—but so are adequate electrical conductivity, high strength, and fatigue resistance.

Cannon Electric, Los Angeles, makers of these electrical plug assemblies, had to find a rod with a delicately balanced combination of mechanical properties to provide the unfailing and continuous performance required. They found it in Anaconda Free-Cutting Phosphor Bronze-610 Rod, developed by American Brass metallurgists to combine the strength, resilience, fatigue resistance of phosphor bronze, and machinability approaching that of free-cutting brass.





MEETING the joint requirements of designers, manufacturing men, and buyers—to achieve high quality and performance while simplifying fabrication and cutting over-all costs—is an important function of American Brass technical specialists. For imaginative and practical help of this kind, see your American Brass Company representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6009

ANACONDA®

COPPER · BRASS · BRONZE
NICKEL SILVER · MILL PRODUCTS
Made by The American Brass Company

Circle 406 on Page 19

ENGINEERING NEWS

SAC Workhorse Will Double as Drone

Pilotless B-47 medium bombers will soon give U. S. air defense systems a full-scale shakedown. The big 100-ton, six-jet drones will be equipped with optical and electronic firing-error indicators to test the military's complete arsenal of ground-to-air and air-to-air antiaircraft weapons. They will also carry countermeasure systems to jam ground radar and confuse electronic and infrared missile-homing mechanisms. Conversion of two of the Boeing-built bombers is being done by Lockheed Aircraft Corp. and Sperry Gyroscope Co. Delivery to the Air Force is scheduled for summer.

No Change in Pay Rates Seen For Government Engineers

Ease in Demand Keeps Money Static

WASHINGTON — The government's ability to recruit and retain engineers during 1958 improved to such an extent that no further pay adjustments are presently being considered, according to the Civil Service Commission. The commission carefully points that no cutba ks in salary are being contemplated either.

Several factors have combined to improve the government's competitive position:

- The 10 per cent general classified pay increase passed by Congress last June.
- Continuation of existing special pay rates, above the minimum, for shortage-category positions.
- Intensified recruitment programs and greater emphasis on coordination of recruiting and co-operation with colleges.

The commission said that other factors, particularly authority to hire high-quality college graduates without work experience at grade 7 instead of grade 5, authority to pay travel and moving expenses of new employees in shortage categories, and the new Government Employees Training Act, should also make it easier to recruit needed engineers and scientists.

A recent study by the Commission showed that the percentage of acceptances to job offers for beginning professional engineering and physical science positions (GS 5 and 7) had increased from 17 per cent in 1954 to 40 per cent in 1958; the acceptance rate for beginning engineers was 37 per cent and for physical scientists 49 per cent.

CSC said it is keeping a close watch for developments which might indicate the need for later pay-rate adjustments. Before making any such adjustments, however, the commission indicated it would need information from agencies which are major employers of engineers and scientists to show that they are not getting enough recruits.

Freshman Enrollment Drops In Engineering Schools

Critical Demand for Engineers Still Exists, Says ASEE

URBANA, ILL.—Freshmen who enrolled in engineering courses last fall numbered 7907 fewer than a year ago—a drop of 11.6 per cent. The decline will not yet affect graduating classes swollen by record matriculations of earliers years. In 1958, 31,216 students graduated compared with 27,748 the previous year.

These figures come from the annual survey of students and degrees conducted by the American Society for Engineering Education in co-operation with the U.S. Office of Education. Engineering students are now less than 7.7 per cent of all American college students compared with nearly 8.5 per cent in 1957. ASEE officials view the figures with some alarm, pointing out that the shortage of trained engineers is still critical.

Graduate enrollments are bucking the trend shown in undergraduate

Circle 407 on Page 19→

... Fluid Power news

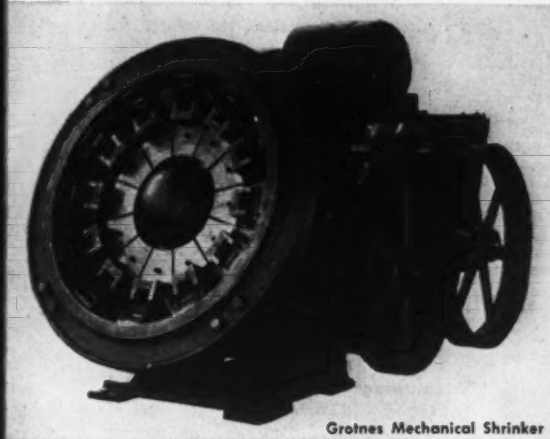
REPORT NO. 11.601
GREATER POWER FOR EXPANDERS & SHRINKERS

From Oilgear Application-Engineering Files

HOW OILGEAR HEAVY-DUTY POWER-PAKS EXTENDED WORKING RANGE OF GROTNES MACHINES

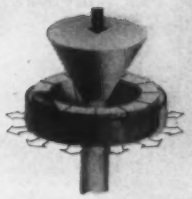
CUSTOMER: *The Grotnes Machine Works, Chicago, Illinois.*

DATA: Grotnes expanders and shrinkers are used for forming and sizing sheet metal parts and heavy rings to tolerances of ±.002" without heat, machining, or waste. Any continuous cross-section part (square, round, oval, etc.) is expanded over jaws mounted in a slotted table. The jaws are moved radially outward by a drawbar-actuated cone, forming or sizing the part by stressing the metal beyond its yield point to induce a permanent set. In shrinking, the jaws are forced inward against the part by a tapered ring or toggle links. World-wide acceptance of this unique method has led to industrial requests for Grotnes machines with greater working forces, longer strokes, more uniform power than are practical or possible with mechanical drives using gear trains and crankshafts.

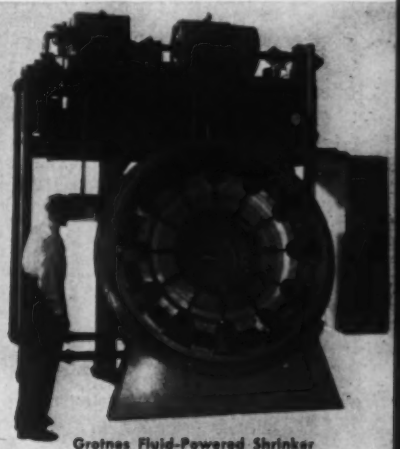


Grotnes Mechanical Shrinker

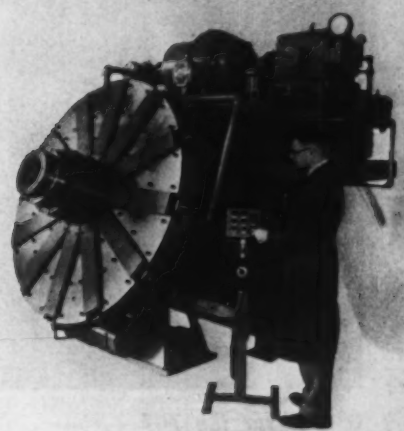
Grotnes Shrinking Method



Grotnes Expanding Method



Grotnes Fluid-Powered Shrinker



Grotnes Fluid-Powered Expander

SOLUTION: Shown above are two Grotnes shrinkers—one mechanically powered, the other Oilgear Fluid Powered for greater tonnage, longer stroke, more uniform power. Note the neat appearance of this new unit with its convenient, simple panel for precise, automatic control. Shown, right, is one of a new line of Grotnes expanders designed specifically for Fluid Power operation. Capacities range up to 1,580 tons on the new expanders; to 800 tons on the new shrinkers—based on 3,000 psi pressure provided by Oilgear application-engineered Heavy-Duty Power-Paks. Performance and control on these new, larger machines has been so outstanding that Grotnes is now equipping expanders as small as 25 tons drawbar pull with Oilgear Power-Paks. This is just one example of Oilgear cooperation and teamwork with designers and builders of machines for industry. An Oilgear Power-Pak is more than just a clean-appearing, unitized assembly of a pump, motor, reservoir, valves and controls . . . it is an efficient, leaktight, easy-to-install, Heavy-Duty Fluid Power system based on over 35 years of pioneering-engineering-knowledge that provides: automatic, electric power conservation; precision-controlled pressures, positions, cycle times; dependable operation; unit responsibility for the entire power system. Because of Oilgear's long reputation for dependable, trouble-free Fluid Power for virtually any application, Oilgear has become a name that all industry trusts . . . and uses.

For practical solutions to your linear or rotary drive and control problems, call the factory-trained Oilgear application-engineer in your vicinity. Or write, stating your specific requirements, directly to:

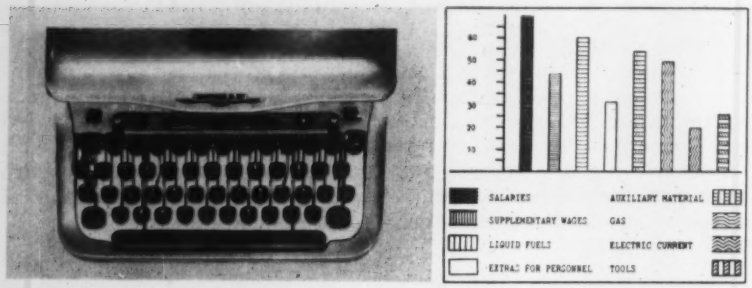
THE OILGEAR COMPANY

Application-Engineered Fluid Power Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

Oilgear application-engineered Power-Paks are also used extensively on hotplate, plywood, pulp-baling, injection molding, extruding, forming, and other presses. Oilgear rotary drive and control systems are equally well accepted in virtually every field of manufacturing and processing. For accurately controlled linear or rotary power . . . for the lowest cost per year . . . check with Oilgear!

figures. Enrollment in master's and doctor's degree programs is up over 14 per cent from 1957. Last year, master's degrees in engineering accounted for 10 per cent of all master's degrees awarded. Of all doctor's degrees awarded last year, 8 per cent were in the engineering field.



Versatile Typewriter Draws Bar Graphs

Words or charts—or even the bar graph shown—are tapped out on this deceptively simple looking typewriter with equal facility. The shift register is occupied by 27 chart symbols which are designed to harmonize with upper-case letters in the standard register. Called Chart-Typer, the machine was developed by Continental Office Machines Inc., New York, to provide a means of typing accurately scaled and aligned symbols on chart paper. A carbon ribbon attachment allows direct offset printing from typed copy.

G Seat for the 707

Passengers end up lying down when preset inertia loads are exceeded in a new safety seat developed by Sabena, Belgian World Airlines. This gives passengers two big advantages in event of plane accident: 1, Supine position is most favorable for withstanding the usual loads, and 2, Center of gravity of the seat is lowered by about 30 per cent, which means it won't be torn loose from the plane nearly as easily as conventional forward or aft-facing seats. Belgian CAA has tested the seat under 21-g loads; U.S. regulations require 12-g proof of seat attachment. Present version of the seat, which Sabena will install in its new Boeing 707s, is fully automatic, but controls permitting activation from the pilots' compartment can easily be added. On the brighter side, Sabena says the seat beats most others in comfort as well as safety.

Topics

Bicycle built for flying, a project looked upon with less enthusiasm recently than in past centuries, is now receiving serious attention from a few British aeronautical eggheads. A "flying bicycle," just what its name implies, is a prop-driven aircraft powered by pedaling of its riders. An engineer working on the project says, "We are approaching the problem in a sound technical manner and are taking it as seriously as the design of any powered aircraft." He feels the outlook is promising. However, a major problem is manpower. Will two, three, or more men be needed to get the thing into the air and keep it flying?

• • •

Clean conversations are assured by a new telephone with a built-in sterilizing unit that kills bacteria, molds, and viruses on the mouthpiece. When the phone is hung up, its mouthpiece comes to rest on a unit containing a Westinghouse Sterilamp tube, which produces ultraviolet rays. The tube stays on 60 seconds to assure destruction of all germs; it is expected to last about 3 years in average use. Producer of this sanitary instrument is Danco Telephone Co. Inc., New York.

• • •

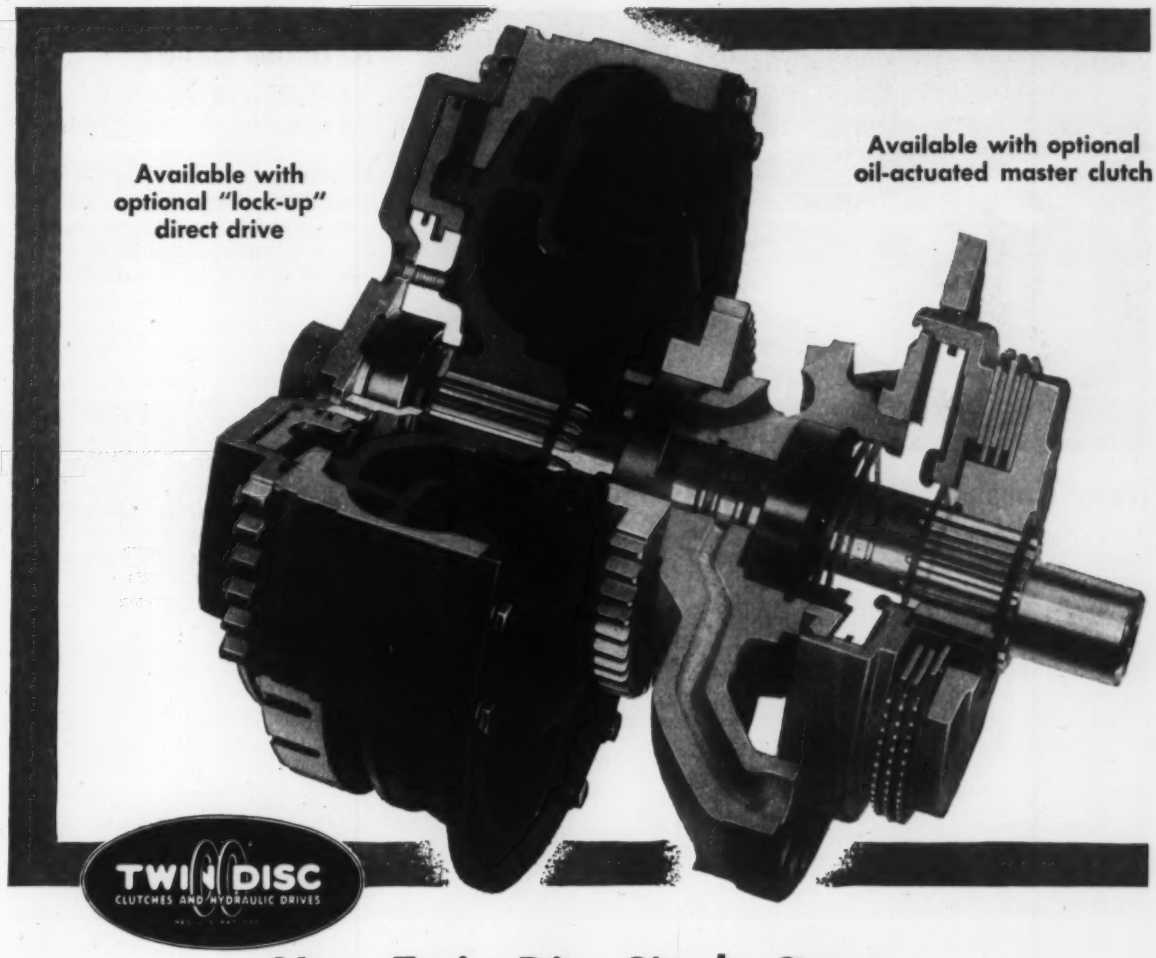
Aerospace, a word coined by the Air Force, designates both the earth's atmosphere and outer space. Gen. Thomas D. White, Air Force chief of staff, explains that since no natural barrier separates these two areas, there can be no operational boundary between them.

• • •

Bigger 21-inch TV screens are promised by a new picture tube developed by Sylvania Electric Products Inc. The tube, in which the safety panel is not a separate piece but is bonded to the face plate, has sharper corners and a flatter surface than a conventional tube. This arrangement enlarges the viewing area by 20 sq in. and also makes the picture more clear.

• • •

Parlez-vous IBM? A methodical business machine can translate from French to English at the rate of three or four words a second. Furnished with a 600-word dictionary, an IBM 704 tackles 1200 words at a time. It runs through its entire vocabulary once, changing French words into "items" that are restored to their proper sequence by means of coded instructions with each English word. Instructions deal with idioms, rules of grammar, and placement of adjectives. After all instructions have been followed, English words are assembled and printed as sentences.


Available with optional "lock-up" direct drive
Available with optional oil-actuated master clutch
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

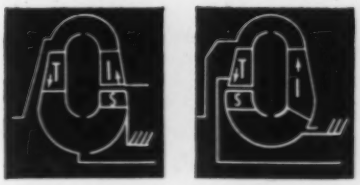
New Twin Disc Single-Stage
STRIPPED Torque Converters

Efficiency, adaptability, long life — all in one low-cost, compact package — that's the new Twin Disc 1100 and 1300 Series Torque Converter. It's furnished as a "stripped" unit to be designed into any drive line of appropriate capacity. Wherever torque conversion is desired—shovels, cranes, tractors, materials handling equipment — this new unit provides compactness and low cost without sacrificing heavy duty construction.

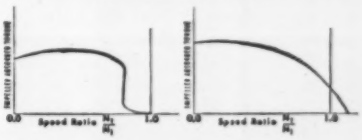
The 1100 Series is rated for engines producing up to 188 hp at 3700 rpm and up to 265 lb.-ft. of torque; the 1300 Series, up to 212 hp at 3200 rpm and up to 330 lb.-ft. Five torque ratings permit close matching of converter to engine for maximum efficiency and fuel economy. Torque converter eliminates engine lugging and stalling . . . cushions out shocks and vibrations . . . automatically matches power to load demands.

Considerable design latitude is provided by two optional circuit designs (see torque absorbtion characteristics at right).

This new "stripped" single-stage converter enables original equipment manufacturers to offer the sales appeal of torque converter drives at the lowest possible cost. See our catalog in Sweet's Product Design File, Folio 6a/TW. Write Rockford office for full details.



Schematic drawings of the two types of single-stage circuits. The Type 1 (outflow) circuit is at left. Type 6 (inflow) is at right.

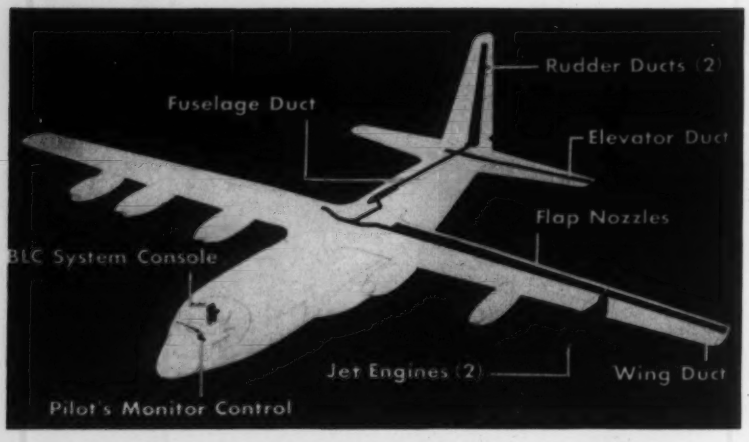


A comparison of the torque characteristics of the Type 1 circuit (left) and the Type 6 circuit. The Type 1 circuit unloads the engine quite abruptly at a speed ratio of about .825. The Type 6 design allows a no-load speed ratio of 1.15:1.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

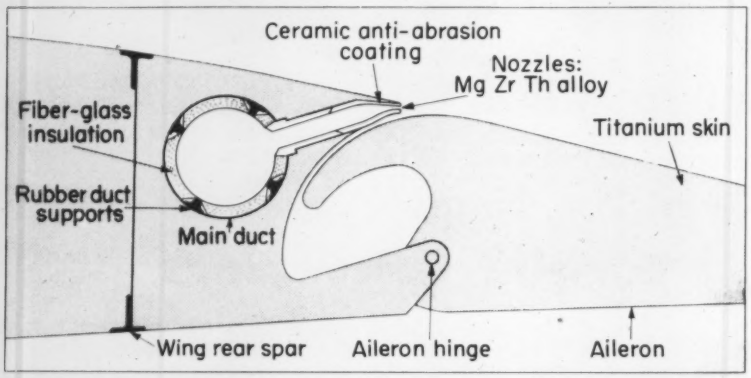
BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND • DALLAS • LOS ANGELES • NEWARK • NEW ORLEANS

Circle 408 on Page 19



Troop Transport Tests Boundary-Layer Control

Quick takeoffs from short runways are predicted with a new test version of Lockheed's C-130. The big transport will use boundary-layer control air on wing surfaces to increase lift. Rudder and elevator surfaces will also be supplied with high-energy boundary-layer air to keep controls "active" at the relatively slow landing and takeoff speeds. Two turbojet engines, mounted in pods beneath the wings, will supply all the air that's needed. Addition of the pods is not expected to seriously affect speed or range of the plane, which normally carries four Allison T-56 turboprop engines. Since boundary-layer control will not be used for normal flight operations, the auxiliary jet engines will be removed when not in use.



Tiny Timer Tends Missile Parts

Miniaturized elapsed-time indicator, less than 1¼ in. long, contains a 1-w synchronous motor that runs on aircraft accessory current (115 v, 400 cycles), a jeweled gear train with 180 million to one ratio, and an internal reset mechanism. It will record up to 1000 hrs, to give needed information on aircraft and missile component reliability. It withstands 10-g vibration at 500 cps, a shock of 15 g, and works in any temperature from −40 to +165 F. The 1.2 oz timer, produced by Elgin Micronics Div., Elgin National Watch Co., Elgin, Ill., can be mass-produced at reasonable cost. The unit is incorporated in current weapons systems.

Ships To Be Given Wings For Efficient Sea Duty

Advantages of Hydrofoils Are Applied to Larger Vessels

BETHPAGE, N. Y.—Hydrofoils—the underwater wings that increase speed and performance of ships—are to be incorporated in two vessels being built by Grumman Aircraft Engineering Corp. One will be a 50 to 100-ton test model, scheduled for completion in 1960, to demonstrate operation on the open sea. The other, to be launched in a few months, will be a 24-ft Navy vessel with supercavitating hydrofoils. Since applications of the hydrofoil principle have heretofore been confined to relatively small craft, these two vessels may make a significant splash in the world of water transportation.

Grumman has a quarter-million-dollar contract from the Maritime Administration to continue its study of the feasibility of using hydrofoils to increase speed and comfort of ocean travel. So far, these ships have proved their seaworthiness.

Leo Geyer, who has charge of Grumman's hydrofoil development programs, says that hydrofoil craft can operate at more than three times the speed of fast conventional vessels while maintaining the same ratio of payload to gross weight, and can maintain cruise speeds in rough seas with prospects for improved passenger comfort.

The "scale-model" test vehicle is being designed with two hydrofoil configurations; one or both may employ autopilot equipment. Speed, expected to be approximately 80 knots, will be the immediate design consideration; refinements in hull configuration and cargo and passenger spaces will come later.

The new Navy boat will serve as a test vehicle also in optimizing the design of similarly equipped, larger craft which may have a wide variety of commercial and military functions ranging from passenger and logistics transport to antisubmarine warfare. This fish-bird will not only have wings, but will also be powered by an aircraft engine, a General Electric T-58 turboshaft.

The boat's supercavitating hydrofoils will be assisted by a supercavitating propeller to produce speed in excess of 60 knots.

Photo: Courtesy Electric Boat, Div. General Dynamics Corp.

U.S. Atomic Subs Depend On N/D Ball Bearings In Over 100 Vital Positions!

Some of the most unique and precise equipment ever engineered is in United States atomic subs . . . with New Departure bearings in many vital positions!

In the submarines' guidance system, New Departure gyro ball bearings help contribute to unerring undersea navigational accuracy. These bearings have been credited with reducing random drift rate to 0.25 degrees per hour.

Many of the atomic power plants that have supplied record-breaking propulsion without refueling, are equipped with New Departure precision ball bearings in reactor control arms, water pumps, and other essential applications.

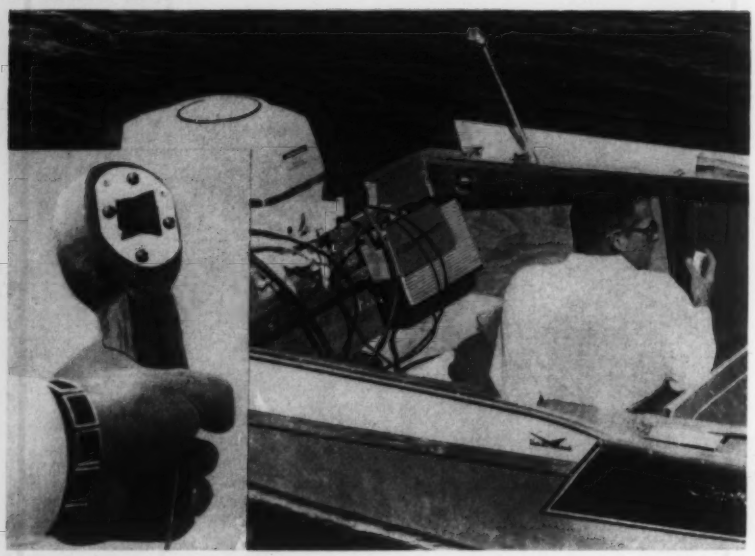
If you have a vital precision bearing problem, why not call on N/D, too? New Departure's advanced facilities for research, development and production, are your assurance of the ultimate in ball bearing design and precision manufacture.

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Circle 409 on Page 19



Power Steering Lets Outboard Skipper Roam Decks

Remote-control switch at the end of a cable actuates an electric steering control developed by Huppower Div., Hupp Corp., Detroit. Switch's three positions (right, left, and neutral) operate a forward-or-reverse, 6 or 12-v dc motor which controls outboard motor through suitable linkage to steer the craft. The unit holds the tiller in the last chosen position, leaving the skipper's hands free for other duties. He can move about the boat to choose the best vantage point for steering through narrow channels or can go under cover during storms.

Air Force Seeks Simple Environmental Test Specimens

CHICAGO — Wanted: Objects that change color, hardness, or dimensions to measure environmental conditions like:

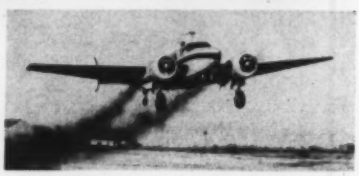
Humidity	Zero gravity
Cold	Ozone
Low pressure	Salt spray
Thermal shock	Heat
Rain	Aurorae
Sand and dust	Ionization

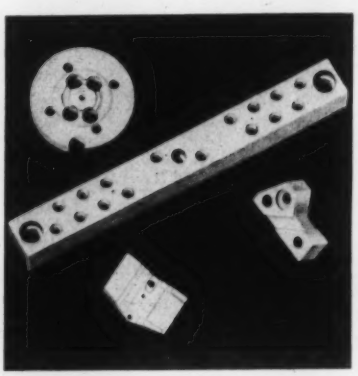
The objects, to be called Standard Environmental Test Specimens, must indicate the duration of the "stress," as well as its severity, by a simple change of any physical characteristic. The specimen's reactions must be a known function, not necessarily linear, of the stress intensity.

Wright Air Development Center, Dayton, Ohio, is sponsoring research by the Cook Electric Company's Inland Testing Laboratories, Morton Grove, Ill., to find a family of these specimens. Comments and suggestions are welcome. The specimens will be used in development of new test facilities, calibration of test facilities, correlation of performance between facilities, correlation between natural and test conditions.

Junior JATO Boosts Small Aircraft

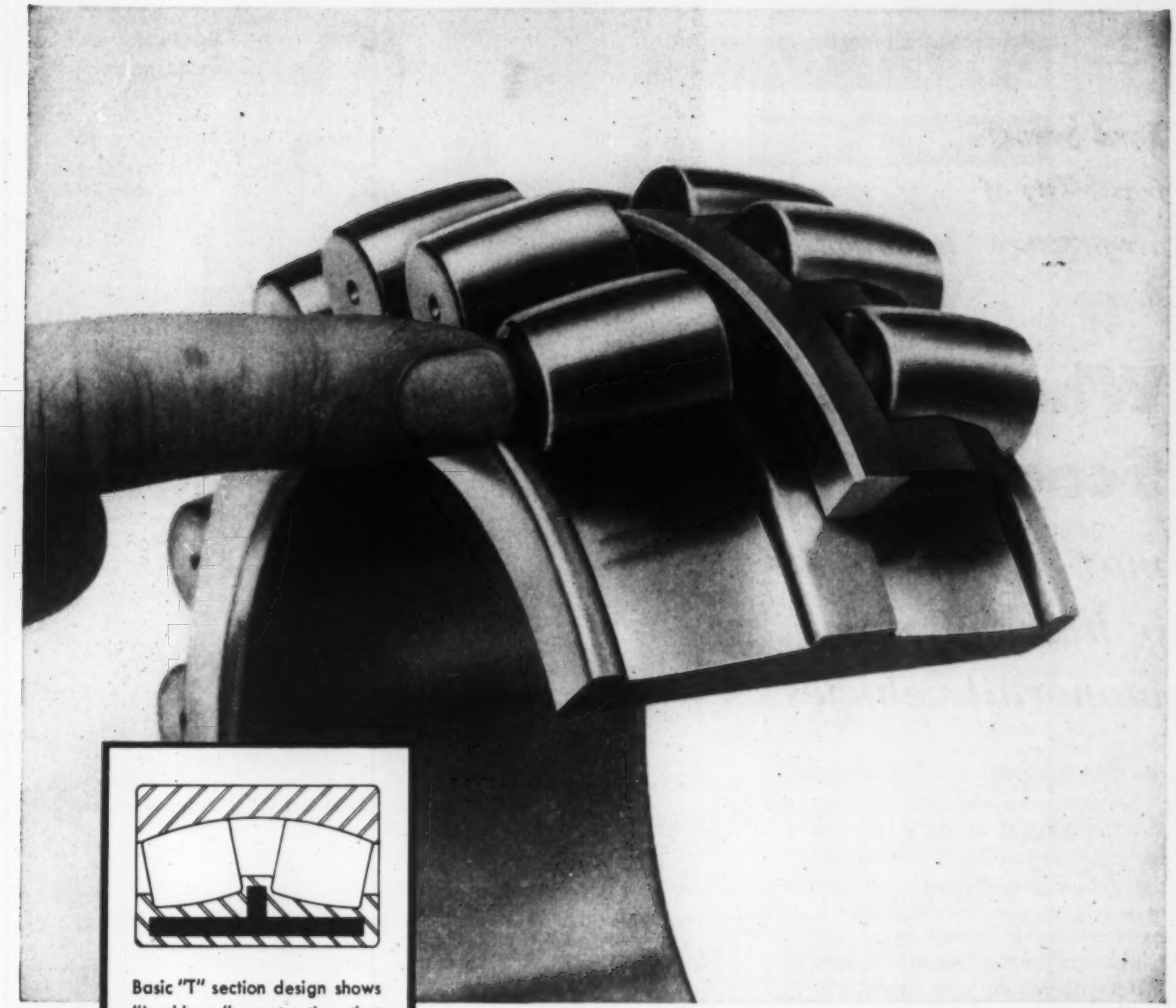
Rocket power for emergency use is now available for aircraft weighing less than 10,000 lb. Boost for high-altitude or heavy-load take-off is generated by Aerojet's 250-lb-thrust Junior JATO rockets. "Shelf life" of rockets is 500 flight hours or one year.



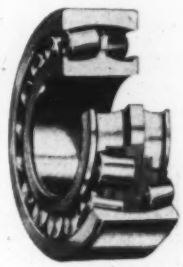


New Insulation Takes 1550 F

Excellent dimensional stability at 1550 F and easy machinability are outstanding characteristics of a new ceramoplastic electrical insulating material. Its high-temperature limit represents an improvement of 60 per cent over previous ceramoplastics, according to its developer, Mycalex Corp. of America. Called Supramica 620, the material has a fine, uniform texture which permits complex machining to 0.0001-in. tolerances. Other characteristics (ASTM test procedures): Dielectric strength, 250 v/mil; arc resistance, 300 sec.



Basic "T" section design shows "backbone" construction that insures positive roller guidance and stability without skewing under all load conditions.



Send for the new Torrington Spherical Roller Bearing Catalog #258.

For roller stability...

there's nothing like "the bearing with the backbone"

The only *positive* way to guide rollers is by an integral center guide flange—backbone of the *Torrington* Spherical Roller Bearing. No floating ring can match it for stability under heavy radial and thrust loads.

This "bearing with the backbone" insures true rolling motion . . . prevents stress concentration . . . means minimum friction. It makes possible open-end cage design, too, with no shrouds to impede circulation of lubricant to bearing contact surfaces. There is less heating and more positive lubrication.

The integral center guide flange is adapted from the same principle used in the design of Torrington Tapered Roller Bearings. This refinement is typical of Torrington's uncompromising engineering that assures you the ultimate in bearing performance. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

Circle 410 on Page 19

Ford proves feasibility of air-pressure "levitation," says

Wheelless Scooter

may be forerunner of high subsonic monorail vehicles

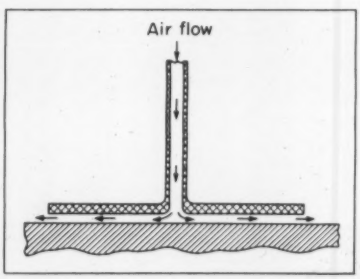
Levascooter, built by Ford, is a demonstration vehicle capable of supporting two men. Three levapads, supplied with compressed air through a hose, lift the vehicle several thousandths of an inch. Air pressure required for "levitation" is surprisingly low: less than 100 psi.

WHILE SPEED of air travel has advanced exponentially during the past decade, ground travel continues at a relative crawl—held in check by mechanical limitations of the wheel and human control factors. What's needed are new concepts in design and hardware that will do for land vehicles what jet engines did for aircraft.

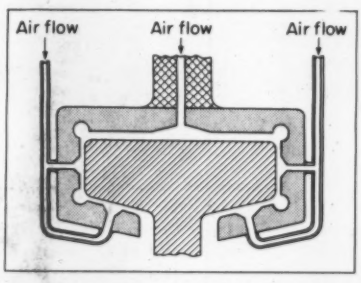
Researchers at Ford Motor Co. think they have an answer: Replace wheels with an air bearing and ground vehicles should be capable of 200 to 500-mph speeds.

The concept is far from fantasy. Air-cushion principles are being studied by a number of industrial organizations, with an interested Defense Department looking over their shoulder. And Ford's experimental Levascooter, presently limited in range by a compressed air hose, is proof that the idea works.

The Levascooter's air bearings, called Levapads by Ford, are flat circular plates with a hole in the middle. Compressed air forced out of the hole forms an air bearing which raises the Levapad a few thousands of an inch. Vehicles supported by this device must travel on a completely smooth surface (concrete is too rough) and are probably best suited for rail transportation. The pads will jump a 1-in. space without difficulty, however. Ford has preliminary sketches of a 16-passenger luxury bus, powered by two turbojet engines, that would operate on a single rail. It would be capable of making a trip between Detroit and Chicago in less than an hour.



Simplicity of the Levapad makes it technically attractive. Elementary unit, above, is merely a flat round plate with a hole in the center. High pressure air, pumped out between the plate and the ground, provides lift.



Levapad on a rail is probably the most favorable application. The top levapad supports the load; two at the sides prevent lateral motion, and bottom two are grippers that prevent the slipper from leaving the rail.

Travel in the bus would be safer than air travel, says Ford, because most failures on the ground would permit the vehicle to slide to a stop. The air supply would function for a short period of time after power failure, and since a number of levapads can be arranged to clamp around a rail, there would be little danger of the vehicle jumping the tracks.

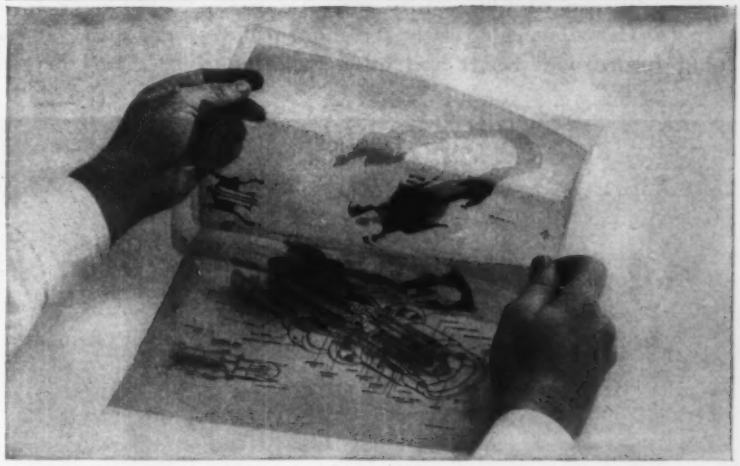
The Levacar is aerodynamically cleaner than aircraft—no wings or tail surfaces—so power requirements would be considerably less. Any conventional means of propulsion could be used: Ducted fans, propellers, or jets. Braking would be accomplished by any one of a number of means: Reversed engine thrust, water scoops, mechanical or magnetic brakes.

Control of a high-speed monorail vehicle would be completely automatic, says Ford.

Dishwasher Goes Ultrasonic

Tough-to-clean egg dishes come clean without hand scrubbing when submitted to the ultrasonic washing cycle in this dishwasher. Sequence timer puts the machine through power rinse, ultrasonic wash, final rinse, and hot-air drying cycles in 12 to 15 min—as opposed to 25 to 30 min for a conventional machine. Vanguard, as the dishwasher is called by developer, Narda Ultrasonics Corp., Westbury, N.Y., is a roll-around unit which plugs into any outlet and hooks up to standard household plumbing.

DRAFTING TRENDS



Color overlays using POST's new Vapo Chromtex color foils give this intricate drawing maximum readability with consistent color fidelity.

Color overlays tell faster visual story

Broader use of color overlays is more and more in evidence every day. Many engineers and designers have discovered that color provides a faster visual communication of highly complex subjects in technical manuals, intricate drawings, flip charts, "exploded" views and schematics.

Of course, color overlays are not new. But, until recently multiple sets had not reached their maximum performance potential. The Post laboratory has devoted more than two years in perfecting a series of ten color foils that meet the most rigid standards. Multicolor sets of films are now produced easily and quickly on any standard white print machine (dry diazo process). These new Post products are called Vapo Chromtex.

Post's technicians successfully eliminated difficulties previously encountered in some of the diazo films on the market, developing consistent color fidelity and the proper brilliance for most effective readability. Post's Vapo Chromtex films come in ten vivid colors: black, red, green, blue, orange, brown, magenta, cyan, yellow, and violet. These clean, bright colors offer a range that is broad enough to cover even the requirements of the most intricate graphic communication.

Unusually sharp image detail

Post Vapo Chromtex has a special acetate base which gives the necessary strength to resist buckling, and has desirable extra stability to insure accurate registration. Use of this base also provides a flat, uncurled print. Equally important, Post's Controlled Coating formulations assure unusually sharp image detail with clear, unclouded backgrounds.

Chromtex also offers good resistance to normal light, hence less image fade. This color foil series falls naturally into your normal reproduction routine. Each of the ten colors fully develop in one pass, and can be conveniently handled by any operator of ammonia process reproduction equipment.

Sample prints, processing data sheet available

If you want to know more about color overlays or if they have been a problem in the past, we will be glad to send you Post Vapo Chromtex sample prints and processing data sheet. *Write to Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.*

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

Circle 411 on Page 19

THIS MUCH MORE in '59

Expansion was not the order of the day during the past year, but it was in this period that the growing sales of "Double Diamonds" required the addition of 60% more manufacturing space. Hence, we now enter the more promising future with better and more facilities to serve as your "gear department" or to fill your gear orders with "Double Diamond" Gears that are built *to produce low installed cost... to serve economically and dependably on the job for which you buy them... and to do credit to your product and your reputation.*

May we send you this catalog of the gear types in which we specialize: helical gears, flywheel starter gears, straight bevel gears, straight spur gears, angular bevel gears, hypoid bevel gears, gear assemblies, zerol* bevel gears, spiral bevel gears, and spline shafts?

*Reg. U. S. Pat. Off.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Circle 412 on Page 19

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Accelerometers, Edit. 164
Adhesives, Edit. 159
Aluminum and alloys, Adv. 45
Amplifiers, Edit. 149
Axles, Adv. 59

Bearing materials, Adv. 27, 159, 161
Bearings, ball, Edit. 158; Adv. 11, 13, 70, 88, 173, 179
  linear motion, Edit 146; Adv. 161
  needle, Adv. 13, 68
  rod-end, Adv. 164, 177
  roller, Adv. 13, 68
  sleeve, Adv. 159
  thrust, Adv. 13
Belts, transmission, Adv. 37, 87
Blowers, Adv. 63
Books, Edit. 170; Adv. 168, 171, 184
Brakes, Adv. 179, 183
Brass (see Copper and alloys)
Brazing, Edit. 26
Bronze (see Copper and alloys)
Bushings, Adv. 159
  ball, Edit. 146; Adv. 161

Cams, Adv. 68
Capacitors, Adv. 71
Carbon and graphite parts, Adv. 46
Castings, die, Adv. 69, 160
  iron, Edit. 27; Adv. 72
  light alloy, Adv. 69, 89, 160
  malleable iron, Adv. 72, 78, 79
  sand, Adv. 72
  steel, Adv. 72
Ceramics, Adv. 30
Chain, conveyor, Adv. 166
  transmission, Adv. 80, 166, 169
Circuits, hydraulic, Edit. 108
Clamps, Edit. 148; Adv. 185
Classified ads, Adv. 175, 186
Clutches, Edit. 152; Adv. 9, 172, 179, 183
Coatings (see also Finishes)
Coatings, protective, Adv. 80
Contactors, Edit. 162; Adv. 46
Control systems, hydraulic, Edit. 123
Controls, electric, Edit. 158, 162, 163; Adv. 31, 42, 92, 163, 164, 178, 181, 184, 185, back cover
  hydraulic, Adv. 7, 34, 53, 61
  mechanical, Edit. 176; Adv. 62
  pneumatic, Adv. 1, 34, 53, 82
Copper and alloys, Adv. 5, 45, 159
Counters, Edit. 150
Couplings, fluid, Adv. 179, 183
  shaft, Edit. 146; Adv. 56, 165
Cylinders, hydraulic, Adv. 34, 85
  pneumatic, Adv. 34, 82, 85, 185

Deep-hole drilling, Edit. 103
Drafting equipment, Edit. 167, 168; Adv. 15, 44, 178, 180, 182
Drive shafts, Edit. 102
Drives, adjustable speed, Adv. inside back cover

Electric equipment (see specific type)
Energy absorbers, Edit. 116
Engineering department (see Management or Drafting)
Escape systems, Edit. 22
Expanded metals, Adv. 74
Extrusions, Adv. 47, 190

Fans, Edit. 138; Adv. 63
Fasteners, bolts, nuts, screws, Edit. 150, 152, 156; Adv. 26, 35, 77, 94, 177
  insert, Adv. 66, 81
  locking, Edit. 161; Adv. 66, 177, 181
  pin, Edit. 146; Adv. 181
  rivet, Adv. 81
Filters, Adv. 160
Finishes (see also Coatings)
Finishes, protective, Adv. 30, 185
Fittings, pipe, tube, and hose, Adv. 179, 183
Fluids, hydraulic, Adv. 33
Forgings, Adv. 45, 190

Gages, pressure, etc., (see Instruments)
Gaskets, Adv. 52
Gears, Edit. 133; Adv. 16, 29, 162, 181, 182

Heat exchangers, Adv. 41
Heaters, Adv. 180
Hydraulic equipment (see specific type)

Ignition coils, Edit. 165
Instruments, Adv. 84
Insulators, Edit. 174

Lathes, Edit. 138
Linkages, Edit. 174
Lubricants, Adv. 33
Lubrication equipment, Edit. 160; Adv. 160, 178

Machines (see specific type)
Magnesium and alloys, Edit. 137
Management, engineering, Edit. 96
Meetings, Edit. 35; Adv. 189
Metals (see specific type)
Motors, electric:
  fractional and integral hp, Adv. 48, 60, 180
  subfractional hp, Edit. 153; Adv. 182
Mountings, vibration and shock, Adv. 51

Packings, Adv. 27, 47
Perforated metals, Adv. 168
Plastics, Edit. 148, 166; Adv. 47, 52, 57, 58, 83
  reinforced, Adv. 36
Plastics molding, Adv. 36, 52, 83
Pneumatic equipment (see specific type)
Powder metallurgy, Adv. 46, 159
Power supplies, Edit. 169
Processing equipment, Adv. 27, 170
Pulleys (see Sheaves)

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

Pumps, hydraulic, Edit. 154; Adv. inside front cover
pneumatic, Edit. 138; Adv. 176

Recorders, Edit. 167, 168
Rectifiers, Edit. 137, 159, 164
Reducers, speed, Adv. 162, inside back cover
Regulators, flow, Adv. 61
pressure, Adv. 181
Relays, Edit. 158; Adv. 31, 71, 92, 163, 178
Resins, Edit. 148, 157; Adv. 57, 58
Resistors, Edit. 157; Adv. 71, 180
Rheostats, Adv. 71
Rubber, Edit. 138; Adv. 37, 51, 87
Rubber molding, Adv. 47, 178

Screws, power, Edit. 102
Seals, Edit. 101, 156; Adv. 170
mechanical, Adv. 27, 47
Servo motors, Edit. 137, 162
Shafts, flexible, Adv. 62
Shapes, special, Adv. 86
Sheaves (see also Pulleys), Edit. 152
Small parts, Adv. 86, 160
Sockets, Edit. 151, 153
Solenoids, Adv. 53
Spray nozzles, Adv. 177
Springs, Edit. 116, 124; Adv. 64
Starters, motor, Adv. 42
Steel, Adv. 2, 45, 54, 64, 93, 183
stainless, Adv. 91, 167, 190
Switches, Edit. 155, 161, 163; Adv. 31, 71, 185, back cover
Swivel joints, Adv. 179, 183

Terminals, Adv. 185
Testing, Edit. 146
Thermal stresses, Edit. 125
Timers, Edit. 158, 176; Adv. 92, 178
Tips and techniques, Edit. 107, 121
Titanium and alloys, Adv. 21, 45, 54, 74
Tolerances, Edit. 131
Torque converters, Adv. 9
Transformers, Adv. 71
Transistors, Edit. 137
Transmissions, adjustable speed, Edit. 122; Adv. 182
Tubing, Edit. 154; Adv. 2, 21, 52, 67, 190
Turbines, Edit. 138

Uncommon metals, Adv. 45

Valves, hydraulic, Edit. 149, 160, 165; Adv. 34, 53, 61, 174, 180
pneumatic, Edit. 149; Adv. 1, 34, 53, 180, 185

Welding, Adv. 90
Weldments, Adv. 90
Wire and wire products, Edit. 146, 176

USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 140

	ITEM NUMBER		ITEM NUMBER
Data Processing	581	Temperature Control	600
Filled Teflon Bearings	582	Silicones	601
Pressure Reducing Valve	583	Utility Pumps	602
Predetermined Counter	584	Universal Coupling	603
Cleaning & Phosphating	585	PVC Piping & Fittings	604
Single-Phase Motors	586	Tiny Mercury Switch	605
Protective Coatings	587	Fasteners	606
Immersion Heaters	588	Reusable Primary Battery	607
Temperature Monitors	589	Phosphate Coatings	608
Brazing Alloys	590	Electronic Equipment	609
Voltage Regulator	591	Hydraulic Piston Pump	610
Phenolic Products	592	Precision Nuts	611
Belt Conveyor Idlers	593	Fractional HP Motors	612
Ceramic Capacitors	594	Milliohmmeter	613
Germanium Transistors	595	Oil, Water & Air Valves	614
Pressure Instruments	596	Friction & Fluid Drives	615
Nickel-Base Alloy	597	Process Pumps	616
Small Panel Instruments	598	Threaded Specials	617
Predetermining Counter	599	Laminated Panels	618

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 146

	ITEM NUMBER		ITEM NUMBER
Quick-Release Pins	619	Metal-Film Resistor	641
Wire Motor Mount	620	Machine-Unit Bearings	642
Flexible Couplings	621	Thermal Time Delay	643
Miniature Ball Bushing	622	Nonflammable Adhesive	644
Vibration Pickup	623	Selenium Rectifier	645
Epoxy Resin	624	Relief Valve	646
Nylon Cable Clips	625	Self-Locking Fastener	647
Miniature Servo Amplifier	626	Limit Switches	648
Check Valve	627	Geared Servomotors	649
Washer Wing Nuts	628	Magnetic Contactors	650
Photoelectric Counter	629	Differential Switch	651
Component Socket	630	Silicon Rectifiers	652
Clutch-Sheave Combination	631	Transistorized Accelerometer	653
Coupling Nut	632	Ignition Coil	654
Caster Sockets	633	Control Valves	655
Reversible Motor	634	Rigid Vinyl Sheeting	656
Rotary Pump	635	X-Y Recorder	657
Tubes and Coil Forms	636	Whiteprint Machine	658
Centrifugal Switch	637	Tube Filing System	659
High-Temperature Bolts	638	Duplex Recorder	660
Metal Shaft Seal	639	DC Power Supply	661
Epoxy Resin	640		

MACHINE DESIGN
Mar. 5, 1959

Circle item number for information on products advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
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problem:

A chemical company, using a cold water heat exchanger to cool caustic soda and sodium hypochlorite, was being plagued by breakage in the 2" dia. glass tubing. Shutdowns occurred about three times monthly . . . each time consumed about 15 extra man-hours to change tubes . . . necessitated additional processing of contaminated hypochlorite.

solution:

A heat exchanger was fabricated from Carpenter Titanium Tubing. Ten-foot lengths of this tubing were vertically submerged directly in each caustic soda processing vat.

results:

Maintenance costs reduced nearly $1500 annually! No tubing failure since Carpenter Titanium Tubing was installed two years ago! Increased production! Improved product quality! With a heat exchanger in each processing vat instead of separate unit, pumps and pump plumbing previously required to transfer highly corrosive fluid, and maintenance problems connected with them, have been eliminated!

Carpenter Titanium Tubing tames corrosion . . . reduces costs

Why not take advantage of the corrosion and cavitation resistance, light weight and high strength of Carpenter Titanium Tubing? It is the *least expensive* tubing you can use under many corrosion influences. It withstands conditions that reduce service life of ordinary metal . . . assures minimum downtime, fewer replacements.

Three commercial grades—C40, C55 and C70—in tubing sizes up to 4½" O.D. are available.

In the food, chemical, pulp, paper and allied industries . . . the long, trouble-free service life of Carpenter Titanium Tubing provides countless opportunities to improve equipment performance and to reduce operating and maintenance costs. Contact your local Carpenter representative or distributor for the full story.

Write for Bulletin T.D. 115A. *Contains complete data on the properties, corrosion resistance and application benefits.*

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Circle 413 on Page 19

DESIGN FOR SURVIVAL

Aircraft escape systems—built around rocket-powered seats and capsules—meet a unique requirement. One successful operation is all that's needed. Here's how designers are giving jet pilots a "second chance."

EVER SINCE man started traveling faster than sound, designers have had trouble in bringing him down, sans airplane, in event of emergency. Today, the odds are still shaky under two flight conditions:

- High supersonic speeds
- Low altitudes

To anyone's knowledge, no pilot has ever bailed out of a modern jet fighter at its limiting dynamic pressure. But plenty of evidence, some still living, has been gathered on escapes attempted at speeds exceeding Mach 1.

Although supersonic escape poses a serious hazard, statistics show that the preponderance of crew fatalities have occurred during low-altitude, relatively low-speed ejections. In 1957, for example, Navy pilots faced the unhappy fact that leaving an aircraft at altitudes below 1000 ft meant almost sure death, regardless of speed or automatic devices. By comparison, ejections at altitudes above 1200 ft were well above 95 per cent successful.

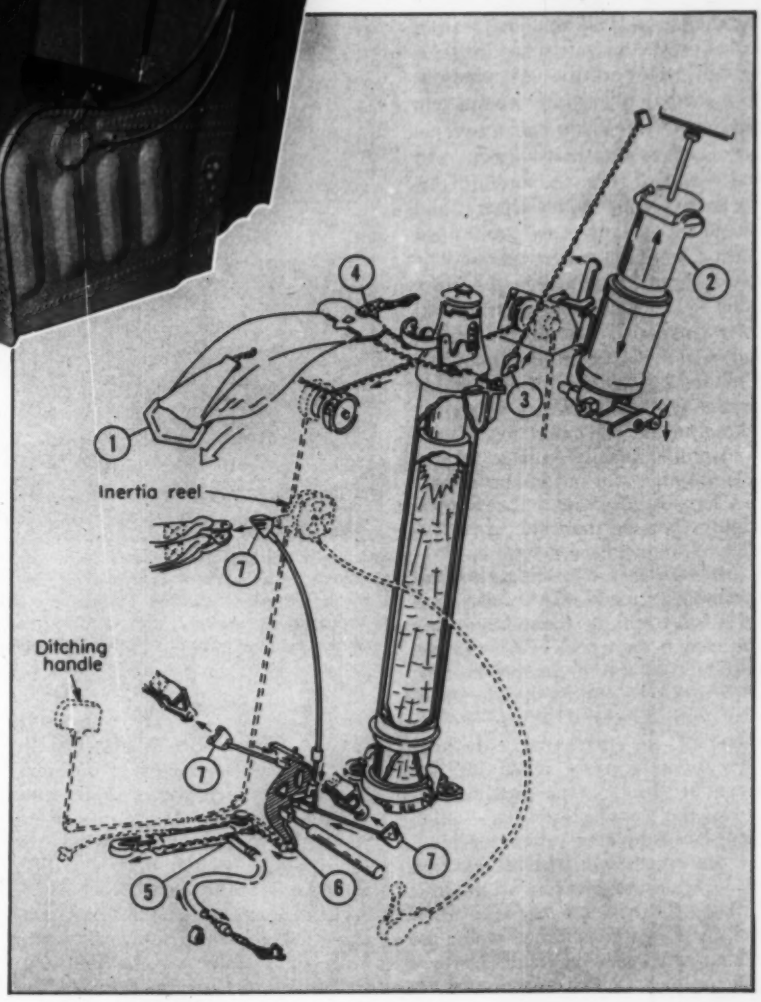
The next round of military aircraft will undoubtedly be fitted with advanced escape systems—which pretty well bracket the performance capability of the plane. In the meantime, designers are refining the low-altitude characteristics of seats in present aircraft. They've already made considerable progress: The Navy's 1957 low-altitude odds have been improved to 60-40 in favor of crew members.

Ejection Seats

All present military aircraft are equipped with ejection seats, and in most aircraft ejection is upward. One notable exception is Lockheed's F-104 in which the pilot goes down and out. This necessitates rolling the aircraft over in event of low-altitude trouble, but prevents the pilot from crashing against the plane's vertical stabilizer during high-speed ejections. Configuration of the plane and ejection system were determining factors.

In all cases, the escape system is completely automatic, once initiated by the pilot. Restraining systems draw his arms and legs against rigid supports, quick disconnects separate him from the plane's equipment, the canopy is automatically jettisoned, and the rocket-powered seat blasts clear of the plane. Drogues and parachutes are deployed explosively with time delays that depend on altitude and speed. The entire sequence, from airplane to airstream,

Power seats are standard equipment on military aircraft. This one, designed by Douglas Aircraft Corp., does everything for the pilot but make the decision. Point of no return occurs when pilot pulls the face-curtain handle, **1**, forward and down. Pneumatic pressure separates bungee inner and outer cylinders, **2**, and downward pressure rotates release arm to disengage canopy latches. Upward pressure jettisons the canopy and pulls the canopy interlock cable, **3**. Continued pulling of the face curtain draws the catapult firing safety pin, **4**, and detonates the main cartridge. When the seat leaves the cockpit, the harness-release actuator firing pin and cable, **5**, are pulled out, and after 3/4 sec delay a harness-release cartridge explodes. Extending piston pulls bellcrank cable, locking bellcrank in open position, **6**. Retaining pins pulled by bellcrank release lap-belt and shoulder-harness fittings, **7**, and pilot separates from seat.



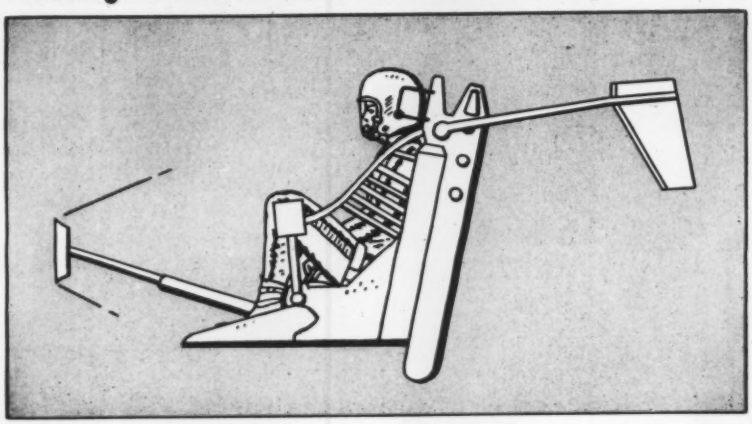
may occur in less than 1 sec.

The clockwork precision involved is provided by an array of remarkable cartridge-actuated devices (CAD) interconnected by a simple network of tubing. Gas generated by the burning of solid propellants operates the entire ejection system, making it completely independent of the plane's hydraulic, pneumatic, or electrical systems.

The typical CAD is a piston-cylinder combination with an integral cartridge containing enough solid propellant to do a particular job. The device is often designed to operate hydraulically or pneumatically under normal conditions (raising or lowering the canopy, for example), with the cartridge reserved for emergency operation (canopy jettison).

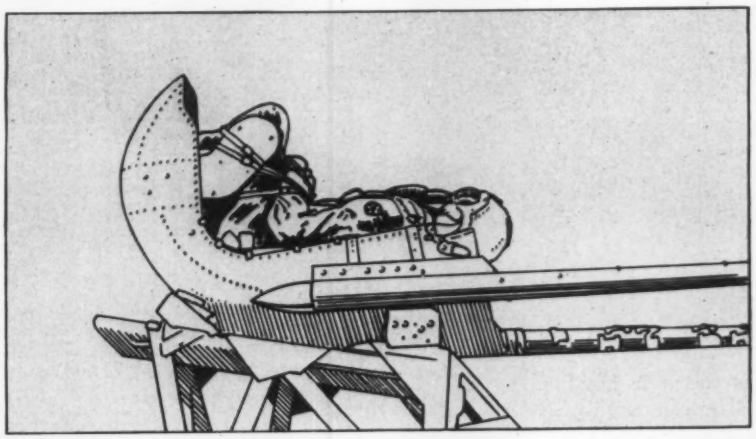
Many of the devices have been standardized by the Air Force and

Two Big Problems: Windblast and Stability . . .



Minimum Airplane

Supersonic seat, developed by Lockheed for the F-104, looked like this during final phase of development. Aft rudder has been replaced by stabilizing fins attached directly to the seat, but the skip-flow generator, resembling a bug deflector, is still used to protect the pilot from windblast. Telescoping boom with deflector on the end is deployed explosively.



Old Chinese Trick

Boom stabilizers, like the stick on a skyrocket, import stability to this Convair escape system. Seat and pilot are raised out of the cockpit and rotated 90 deg by a cartridge-actuated scissors mounting mechanism. Telescoping booms are deployed explosively, and a rocket motor launches the seat away from the aircraft. Supine position of the pilot minimizes windblast and G loading.

are now off-the-shelf items. All ejection seats use a complete selection:

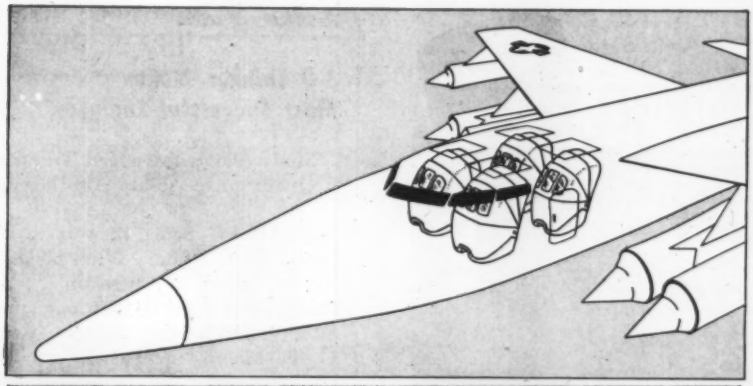
- Thrusters — perform various pre-ejection operations requiring relatively short power strokes. Seat positioning, hatch removal, control column stowage, and canopy unlocking are the usual functions. A typical pull-type thruster, used to unlock the canopy prior to jettisoning, is about 8 in. long, weighs 6 lb, and exerts a retractive force of more than 4500 lb.
- Initiators—supply energy for the initiation of other CAD. They may be gas or mechanically operated and can be equipped with time-delay elements.
- Telescoping Thrusters—jettison escape hatches in big, multiplace aircraft. One end is attached to the hatch; a ball end rests in a socket on the aircraft structure. After full extension, the unit goes out with the hatch, leaving a completely clear escape envelope.
- Rocket Catapults—eject seat and occupant from the aircraft. Firing mechanism, igniter charge, and propellant charge are contained within a fixed, outer tube. The rocket motor, mounted in the inner tube, is attached to the ejection seat in a manner that directs thrust through the CG of the man-seat combination. After an initial thrust by the propellant charge starts the pilot upward, the main rocket motor is automatically ignited. It propels the man-seat out of the aircraft in a forward direction and at a speed slightly greater than the aircraft—thereby reducing deceleration.

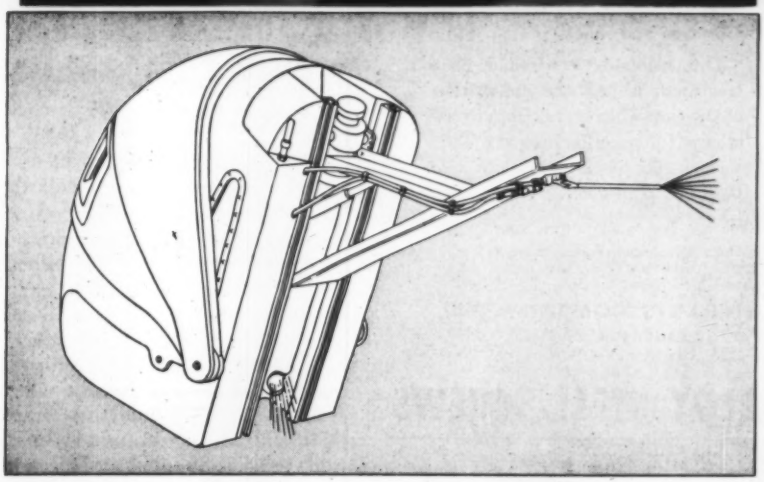
In addition to straightforward mechanical work, CAD also perform other unique functions during the escape sequence. For example, man-seat separation devices are now used to assure positive separation of seat and occupant before deployment of the personnel parachute (designers formerly relied on differential drag). One method involves the use of plastic bags which are placed deflated under the pilot. At the proper point in the ejection cycle, a blast of gas from an initiator inflates the bag, forcibly separating man and seat. Another technique which gets the same results involves the use of a gas-powered rotary actuator. This device is attached to the seat and connected to one end of a strap which passes under and behind the pilot. At the proper instant, the rotary actuator winds up the strap, pulling it taut, and lifts the pilot out of his seat.

All of these mechanisms have one thing in common: They have to perform successfully on the first try. Reliability of cartridge-actuated devices (estimated failure rate for cartridges: 1 in 100,000), plus the design simplicity they add to a system, make present ejection seats a good one-shot bet.

Capsules

Performance capabilities of the upcoming B-70 chemical bomber and F-108 interceptor (Mach 3,





100,000 ft) will require the use of crew capsules. Prototype capsules for the currently operational B-58 are also nearing the hardware stage. Prior to this, the only capsule ever installed in an aircraft was in the Bell X-2. And it was used for just one ejection, which resulted in a fatality. Designers thus have little experience for reference in designing capsule escape systems.

Capsule configuration is the greatest point of speculation. Detailed studies of drag-weight ratios, aerodynamic stability, separation capability, and other basic characteristics are being made on a variety of configurations. Recent designs range from a relatively small and simple encapsulated seat to one which includes the entire nose section of the aircraft. A safe guess would be compromise on the seat side.

One specific design requirement, imposed by the Air Force, discloses the high degree of performance expected from capsules: "The system must provide successful escape without the necessity for wearing any environmental protective clothing such as exposure or pressure suits, etc."

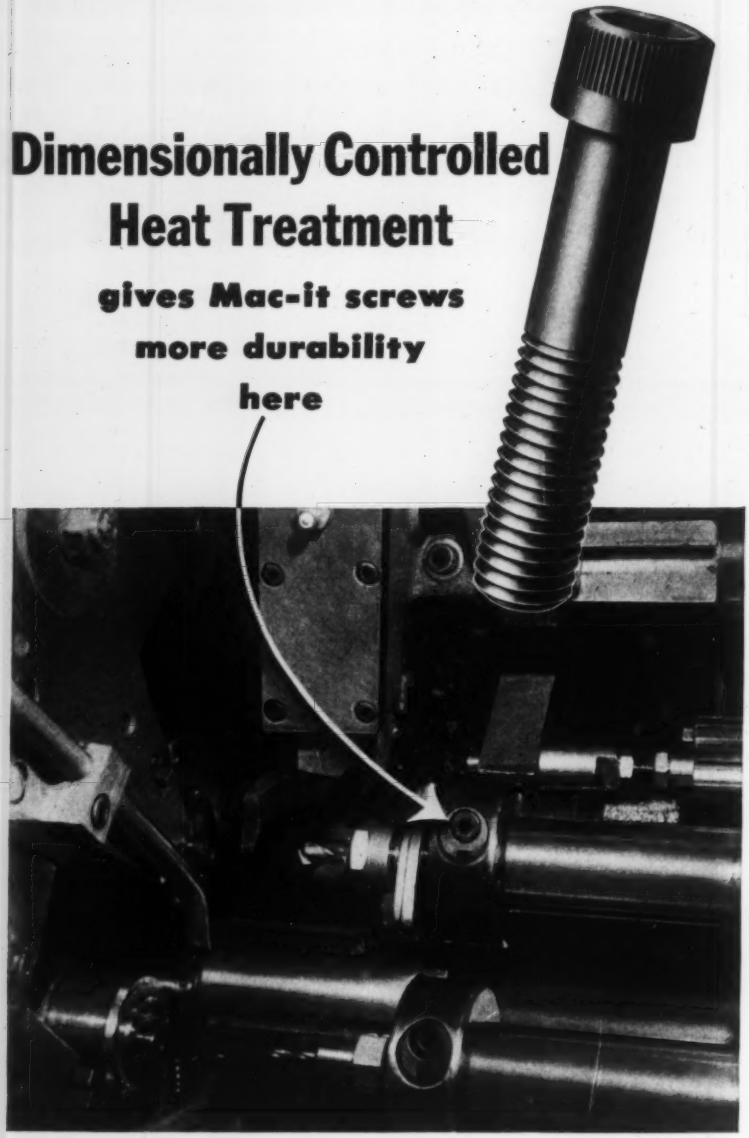
An escape capsule designed in accordance with these requirements would permit the pilot to wear only an anti-g coverall and a protective helmet, an outfit ideal for comfort and mobility. "Tee shirt" operation in high performance aircraft, however, will set severe standards for structural integrity and component reliability. Otherwise, with past experience as a benchmark, decompression will pose a major threat at altitudes above 50,000 ft.

Trend is Toward Taking Cover

Retractable hardtop on Goodyear Aircraft's advanced seat capsule slams shut in 0.2 sec to seal in the pilot during emergency escape. It's also closed at high-altitude flight for pressurization, which eliminates need for bulky pressure suits. Although capsule systems are usually associated with high-speed, high-altitude performance, Goodyear's version is capable of on-the-runway ejections at speeds of 90 to 300 kt. At the other extreme, limiting dynamic pressure is 2400 psf. The capsule weighs no more than present ejection seats, yet carries a complete survival kit for use after descent. It's designed for use in single or multiplace aircraft.

Dimensionally Controlled Heat Treatment

gives Mac-it screws more durability here



The heat treatment specifications for every Mac-it alloy steel screw are determined by its dimensions as well as its intended use.

At Mac-it, large and small diameters are not run through the heat treating processes indiscriminately. Instead, our metallurgists establish a heat treating cycle for each type and size. This assures that every screw has the proper combination of strength, toughness, ductility and resistance to vibration and shock.

Dimensionally controlled heat treatment is just one illustration of the care which is taken in every step in the manufacture of Mac-it screws. That's why Mac-its *hold tight in a tight place.*

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3-D Thinker Makes Most Successful Engineer

Study Shows Advanced Training, Quantitative Ability Also Needed

NEW YORK — Some answers to the important question, "What makes a young engineer successful?" are found in results of a year-long study at Westinghouse Electric Corp. G. E. Moore, manager of student training for Westinghouse, lists these factors as important to a young engineer's success:

- Spatial vision
- Advanced engineering
- Quantitative ability

The importance of spatial vision was particularly stressed, since it is the ability to translate words, analytical terms, and ideas into three-dimensional mental images, and these images into practical devices.

The study also found that development of young engineers cannot necessarily be predicted on the basis of college grades—some average students blossom after several years in the field. Some of this growth can be credited to senior engineers who give the benefits of their experience to fledglings; much of it is the result of disciplined development, such as graduate study.

Mr. Moore's observations were presented in a paper, "1200 Case Studies of Engineering Motivation," at the AIEE Winter General Meeting. The 1200 Westinghouse engineers who participated in the program had experience ranging from one to six years.

New Process Joins Honeycomb By Continuous Brazing

Simple Gas Furnace Brazes Any Length Panel Economically

DALLAS — Production brazing of honeycomb panel is done without carbon blocks, outsize furnaces, or layup time in a new process developed by Temco Aircraft Corp., Dallas. Panels of unlimited length roll through a single gas furnace which preheats at 1100 F and then brazes at 1750 F. Temperature is controlled by regulating the speed at

Circle 414 on Page 19

which the panel passes through the furnace.

Distortion caused by the process, called Temcomb, is not greater than that experienced from other methods. After passing through the brazing furnace, the panels are smoothed and shaped by stretch forming. The brazing temperature is just right for the first step in heat treatment of the precipitation hardening stainless steel used, so that process is continued after stretch-forming. A typical sample formed of 0.008-in., 17-7 PH sheets assembled with 3-20 17-7 PH core has flatwise compression strength of 1900 psi and longitudinal flexure strength of 200,000 psi.

Ferrous Alloy Has Advantages Of Cast Steel, Malleable Iron

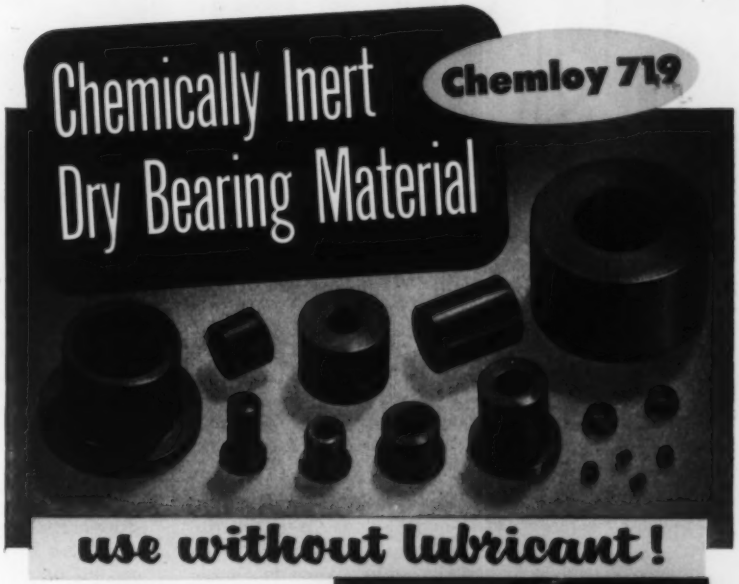
Castings of New Metal May Replace Some Steel Forgings

MILWAUKEE—An alloy that is neither cast steel nor malleable iron but incorporates many of the advantages of each has been developed by Central Foundry Div., General Motors Corp. Because of its 28-million-psi elastic modulus, castings of the new iron-base alloy may replace plain steel forgings. Castability is in the range of that for white iron, and the product does not require extensive heat treatment or costly additives. However, heat treatment can be applied to obtain a wide range of properties.

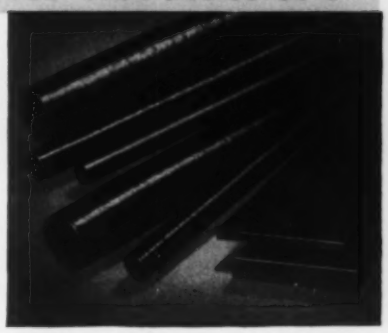
A reversal of silicon-carbon ratio usually found in cast ferrous alloys solves the problem of massive carbide content, making possible the use of as-cast parts. Preferred composition is: 1.70 C, 2.25 Si, 0.40 Mn, 0.10 S, 0.05 P, 0.01 B.

Elasticity of the new material, called CentraSteel, resembles that of steel. Castability is on the order of that for malleable cast iron. Strength is equivalent to pearlitic malleable or as-cast nodular iron and may approach that of cast steel.

Production so far is limited to experimental quantities. Work is under way to solve foundry problems for high volume production.



use without lubricant!



Chemloy 719 is proving to be the most *universal* dry bearing material ever offered to industry:

. . . because its extremely low coefficient of friction invites use where lubrication is impossible, impractical or undesirable.

. . . because it may be used on both sliding and rotating applications over a wide temperature range.

. . . because it is impervious to practically all known chemicals, solvents or corrosives.

. . . because it is excellent under vibration or shock service conditions.

. . . because it will not conduct electricity or cause galvanic corrosion.

Chemloy 719 is available in all basic forms—such as sheet, rod or tubing—or in parts molded or machined to specifications. Get full details.

Request Bulletin T-120 and Price Sheet No. 126, or send b/p or specs. for quotation on molded or machined parts.

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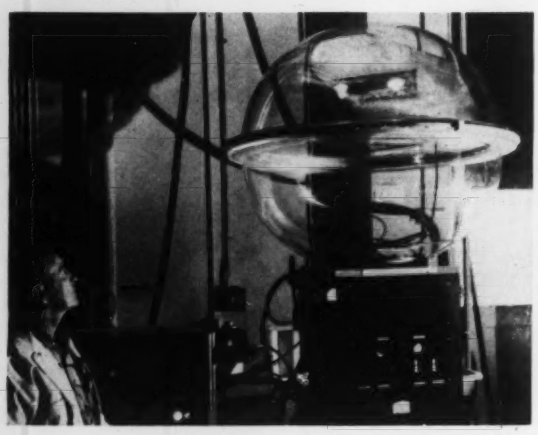
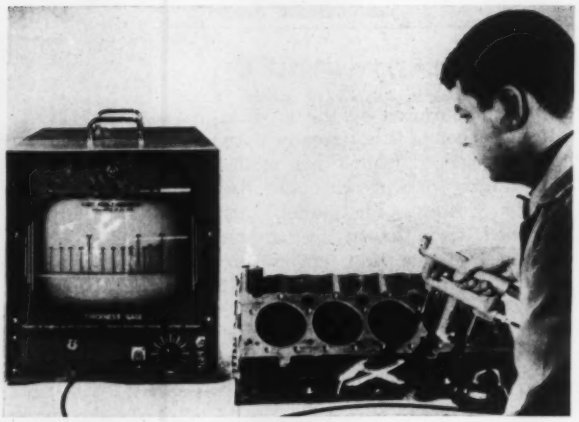
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

Circle 415 on Page 19



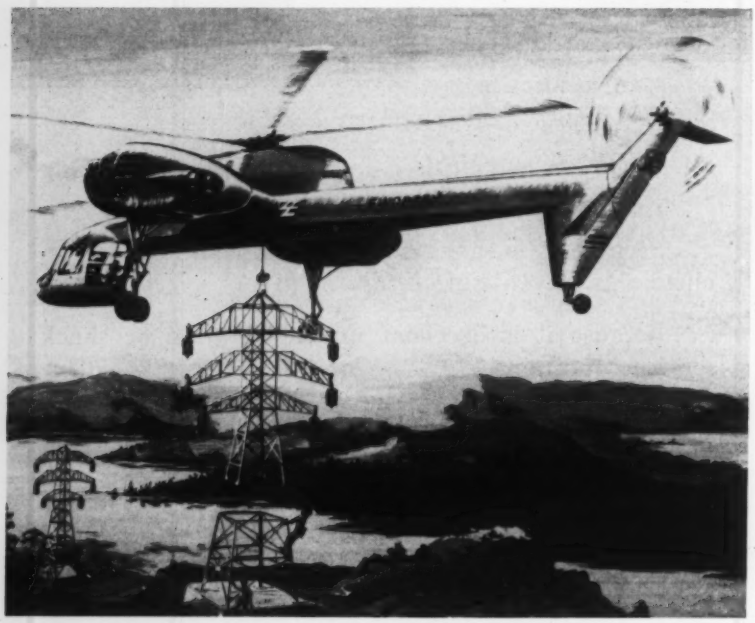
Research in Thin Air

Simulated altitudes of 300,000 ft—inside a 4-ft-diam plastic globe—permit engineers at Boeing Airplane Co. to test radiation capabilities of high-altitude antennas. Problem to be solved involves corona discharge: When too much energy is fed into present antennas, the insulating properties of air break down and part of the radiation energy is dissipated as heat and light. As air pressure is lowered, insulating properties also decrease, making transmission at high altitude exceedingly difficult. Boeing is using the altitude simulator to design antennas for several space craft, including the proposed Dyna-Soar skip-glide vehicle.



Sound Quality Control

Simplified measurement of cylinder-wall thickness is achieved with an ultrasonic gage and oscilloscope readout developed by GM's Process Development Staff. It operates on the principle of frequency resonance with sweeps as high as 4 mc. Thickness is indicated by a single, easy-to-read vertical step in a bright horizontal line, rather than by vertical pips which occasionally need expert interpretation. The new tester can be used on a variety of metals, plastics, and glass to measure the thickness of straight or curved surfaces. It will be used at GM to improve quality control of car-engine castings.



Flying Crane Maneuvers Loads in Rough Terrain

Absence of passenger or cargo cabin will give the pilot the same unobstructed vision that a crane operator has in a new helicopter being developed by Sikorsky Aircraft. The flying crane, officially designated the S-60, will lift a 6-ton payload. Besides construction work in rough terrain, Sikorsky spokesmen predict wide use for the new 'copter in rescue work, cargo transfer, food and medical relief for devastated areas. Twin Pratt & Whitney R-2800 piston engines power the craft, but plans are under way for gas-turbine powerplants in later models.

Bell Interlaces "Talkspurts" To Double Cable Capacity

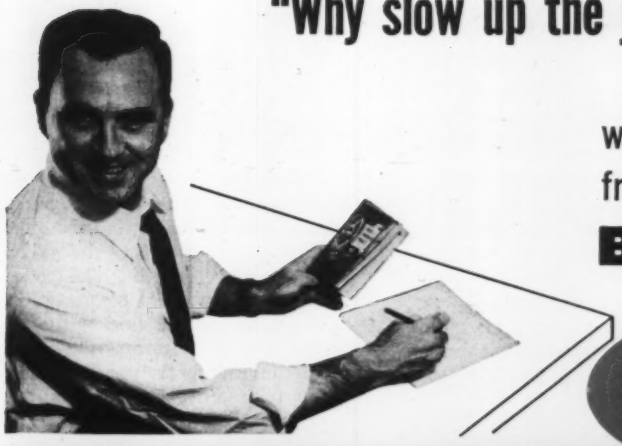
Gaps in Conversation Switch Speech from Channel to Channel

NEW YORK — A new high-speed switching system promises to double the number of telephone conversations carried by underseas telephone cables. Under development at Bell Telephone Laboratories, the system is called TASI, standing for Time Assignment Speech Interpolation.

TASI is essentially a group of high-speed switches that shuttle "talkspurts," i.e., brief bits of conversation, from one channel to another. If, for example, 36 cable channels were available, 72 talkers could be connected. When there are more talkers than channels, the equipment will connect talkers who become active by disconnecting talkers who are momentarily silent. In turn, this disconnected talker will be assigned another momentarily inactive channel when he starts to speak again. A talker will be disconnected only when he is silent.

In a normal two-way telephone conversation, one person on the average will speak only half the

"Why slow up the job with special gears?"



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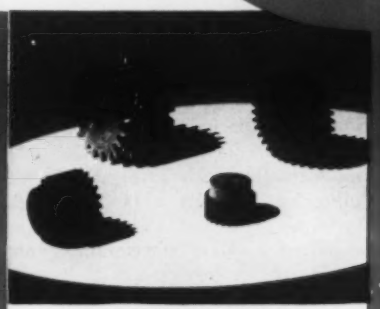
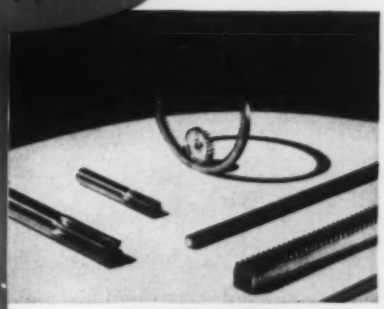
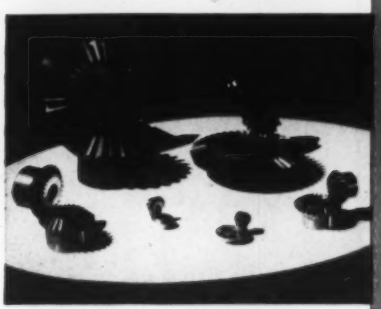


NON-METALLIC SPUR GEARS
14½° and 20° P.A. .938" to 6.667" P.D.

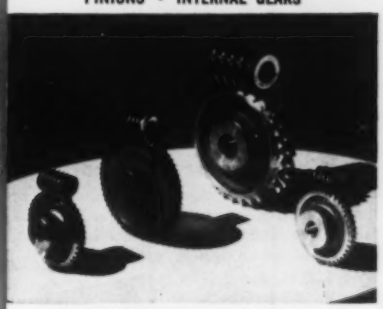


RACK • PINION WIRE
Steel and Brass 14½° and 20° P.A.
PINIONS • INTERNAL GEARS



BEVEL and MITER GEARS
Steel, Iron, and Brass 20° P.A.
.312" to 14" P.D.

STEEL SPIRAL MITERS 1" to 5" P.D.
HELICAL GEARS
Steel and Bronze .333" to 6" P.D.



WORM GEARS Bronze and Iron
.417" to 18" P.D. **WORMS** .333" to 4" P.D.
Soft Steel and hardened and ground steel

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Circle 416 on Page 19

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Circle 417 on Page 19

time, and even while he is speaking, there will be significant gaps and pauses in his speech. Thus, if the two directions of transmission are separated, each transmission path is idle, on the average, more than half the time. If two conversations are interlaced to take advantage of these gaps, greater use can be made of existing facilities.

In practice, the system would not work with only two talkers on one line, since they would frequently be speaking at the same time. However, where a larger number of channels is available, such as in a submarine telephone cable, an averaging effect occurs. This means that at any instant there is a greater probability of sufficient "free time" to accommodate the larger number of conversations. Increasing the capacity of a 36-channel system to 72 channels is therefore more feasible with TASI than doubling the capacity of a 5-channel system.

When a talker starts talking on a TASI circuit, his voice actuates a speech detector. The speech detectors are scanned by a control circuit similar to a modern digital computer. When a talker becomes "active," this control circuit initiates a coded tone burst, consisting of a group of four audio tones which precedes the voice over an available cable channel. After the tone burst, which lasts only 10 millisec, the control circuit connects the talker to the same channel. The coded tones operate switches to connect the talker to the proper line at the receiving end. Tones are not heard, since the listener is not connected while they are being transmitted. When a talker is not "active" and his channel is needed, another coded tone burst is transmitted over a separate signaling channel and severs the connection.

All of the circuits for TASI are completely transistorized. Terminals for doubling the capacity of the Transatlantic cable will require several thousand transistors of four different types, and tens of thousands of diodes and passive components.

Tiny TV Resists Rocket Forces

Transmission comparable to that from commercial stations comes from this 9-lb, transistorized TV while it is shaken and pounded in simulated rocket flight. The 28-v battery-powered set, developed by Lockheed Missile and Space Div., withstands 10-g vibration, 40-g shock, and 50-g acceleration. Although all components fit into a briefcase, it has a 1000-mi range. The cylindrical camera, 7¼ in. long by 2¼ in. diam, weighs only 42 oz. Set employs AM-FM circuitry instead of conventional FM-FM, and is claimed to give more versatility, high fidelity, and more range with the same transmitter power.

Circle 418 on Page 19→

HERE'S WHY SO MANY ENGINEERS SPECIFY P&B's MH RELAY*

*AND VARIATIONS OF THIS BASIC STRUCTURE SHOWN BELOW

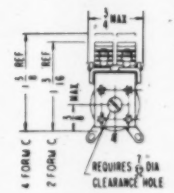
Shown with printed circuit terminals

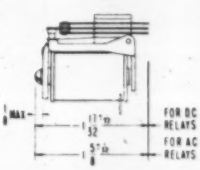
VERSATILITY and adaptability

are prime reasons why designers have made the MH a P&B best seller. This relay series, for example, does yeoman duty in such diverse applications as jet aircraft, street lighting equipment, computers and missile ground controls.

When multiple switching is required...when size, weight, long life and reliability are critical ...our MH relay can usually fill the bill. It's RIGHT for countless jobs, often at countable savings.

Let us send you complete information about this miniature telephone-type relay and the variations we've evolved for special applications. Write or call today.





ENGINEERING DATA/MH RELAY

Insulation: Laminated phenolic.

Insulation Resistance: 100 megohms minimum.

Breakdown Voltage: 500 volts RMS between all elements.

Shock: Up to 30g.

Vibration: Up to 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps.

Ambient Temperature: −45°C. to +85°C. −(65°C. to +125°C. on special order).

Weight: 2½ oz. max. (open relay)

Pull-In: Approx. 75% of nominal voltage.

Pull-In Speed: Approx. 15 ms.

Drop-Out Speed: Approx. 10 ms.

Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

CONTACTS:

Arrangements: Up to 9 springs per stack.

Material: ⅛" silver; also Palladium or gold alloy.

Load: Dry circuits to 5 amps @115V AC resistive.

COILS:

Resistance: 22,000 ohms max.

Power: 100 milliwatts per movable minimum to 4 watts at 25°C. max. (200 mw. min. to meet max. shock/vibration spec.)

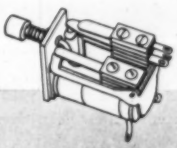
Duty: DC: Continuous. AC: Intermittent (2 pole relay max.)

Voltages: DC: Up to 110 volts. AC: Up to 230 v. 60 cycles.

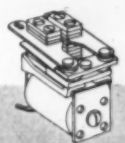
Current: 2.5 ma to 10 amps DC.

P&B STANDARD RELAYS AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

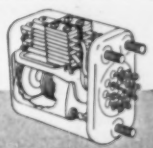
MC FOR RF SWITCHING
For RF switching where intercontact capacitance losses must be minimized. Ceramic contact spacers.



MA LATCHING
Electrical latch; mechanical reset. Small, versatile and offered with selection of contact arrangements.



MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.



MH SEAL-TEMP
Features sealed coil to minimize contact contamination. Available as hermetically sealed relay only.

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Nuclear-Plane Delay Blasted by Critical Congress

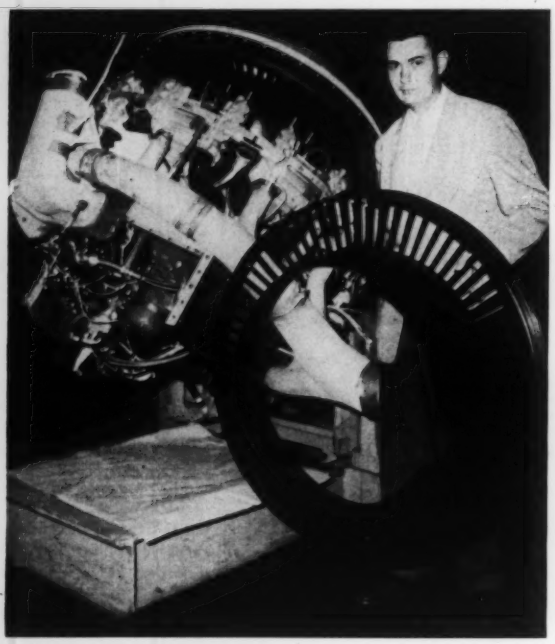
Committee Investigates, Sees Nothing Airborne Before 1962, Blames Interservice Rivalry and Indecision in "High Places"

WASHINGTON—More fuel has been added to the nuclear-plane controversy, this time by the Joint Committee on Atomic Energy. The committee has just concluded a series of detailed hearings "to determine what, if any, concrete plans have been made . . . toward the achievement of nuclear flight." Testifying before the hearings were the Deputy Secretary of Defense, Secretary of the Air Force, Secretary of the Navy, members of the AEC, and director of the nuclear-plane project, Maj. Gen. Donald F. Kiern, USAF.

According to the Committee, "The results of these hearings have left us gravely concerned, both from the point of view of our national security and from the standpoint of world confidence in America's scientific capabilities.

"After twelve long years of effort, during which time substantial technical progress has been made by our hardworking scientists and engineers in the field, we find this almost incredible situation:

- The program still has no firm objectives in development of a nuclear-powered aircraft.
- No target dates have been set for an actual nuclear flight.
- Recommendations of the project director as to funding levels required to get the job done have been virtually ignored.
- Cuts in proposed funding levels for the program in fiscal 1960 will delay the achievement of a ground-test prototype for an additional year, thereby delaying nuclear flight for the same period of time.
- Administrative indecision at high levels, plus interservice rivalries, have plagued the program from the start and have rendered a great disservice to the nation.
- No less than seven advisory committees have been set up in the past decade to review the program, but contractors in the field still have no clear guidance as to where they stand or where the program is going.
- An annual expenditure of $150 million is being made for the ANP program merely as a holding operation to avoid difficult technical and administrative decisions. This is a completely indefensible use of the taxpayers' money.
- The Air Force and Navy, after due consideration by their expert

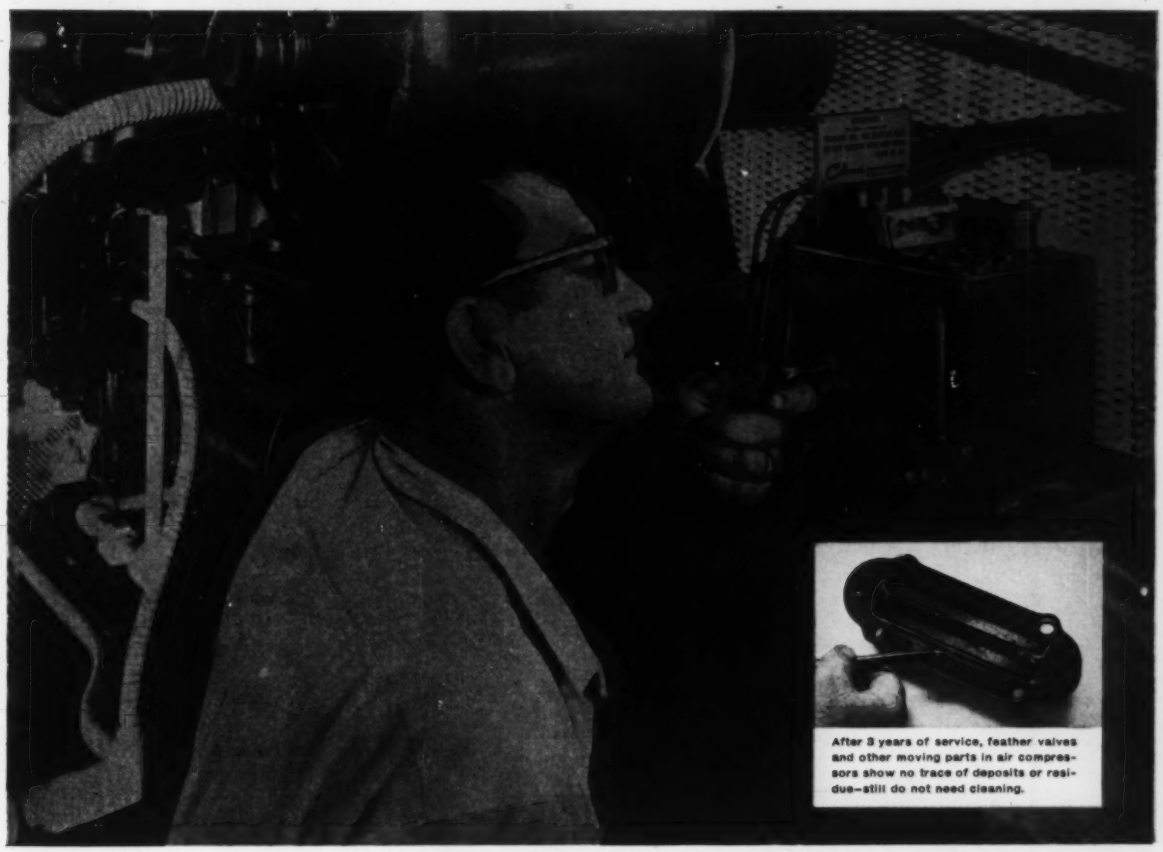


Plastic Ring Keeps 'Copter Cool

No sign of fatigue failure after 15 million cycles of vibration is the record of this glass-fiber contravane ring designed to help cool Sikorsky's S-58 helicopter. Located in the engine compartment behind the cooling fan, the contravane directs cooling air uniformly over the big 'copter's radial engine. Success of the new plastic part, which was laminated by Fibremold Div., Hampden Brass and Aluminum Co., has led Sikorsky engineers to predict wider use of glass-fiber in later helicopter designs.

Rugged Service for LOX Ducting

End-to-end temperature gradients are extreme in the liquid-oxygen ductwork used in Jupiter missiles. Designed to carry LOX from pump to thrust chamber, the duct shown here operates with one end at the frigid temperature of liquid oxygen (−297 F), the other at plus several hundred deg F. Metal in the duct is A-286, a special high-temperature alloy made by Allegheny Ludlum Steel Corp. The alloy has high strength-weight ratios at both high and low temperatures. Inset shows close-up of Jupiter ducting.



After 3 years of service, feather valves and other moving parts in air compressors show no trace of deposits or residue—still do not need cleaning.

"Cellulubes eliminate fires and explosions ... keep compressor parts clean"

says MR. T. E. DANIEL, Foreman, Cypress Compressor Station
Trunkline Gas Company, Cypress, Texas

"Since using Cellulube 220 in our air compressors we have never experienced or had any indication of fire or explosion in our compressed air systems," continues Mr. Daniel.

Installed at Trunkline's Cypress Compressor Station when it opened three years ago, Cellulubes thus provide an authoritative 7800-hour operating record that indicates not only efficient and far safer operation, but substantial savings as well. Mr. R. C. Carter, Trunkline's Compressor Department Superintendent, describes them thus:

"First and most important, of course, is the elimination of any risk to our personnel—from fire, explosion, or fragmentation. Secondly, we save on heavy equipment replacement costs, and thirdly, down-time losses.

"A major savings is in preventive maintenance. Formerly, we completely disassembled and cleaned air compressors every six months. Cellulubes keep machinery so clean that this interval has been indefinitely extended, and so far we've saved at least 60 man-hours. Finally, Cellulubes never get 'dirty,' nor do they burn away by friction or compression."

Cellulubes . . . the *safe* lubricants and hydraulic fluids . . . are available in six controlled viscosities. If you'd like a sample for evaluation, please let us know the application involved.

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economy... specify SP

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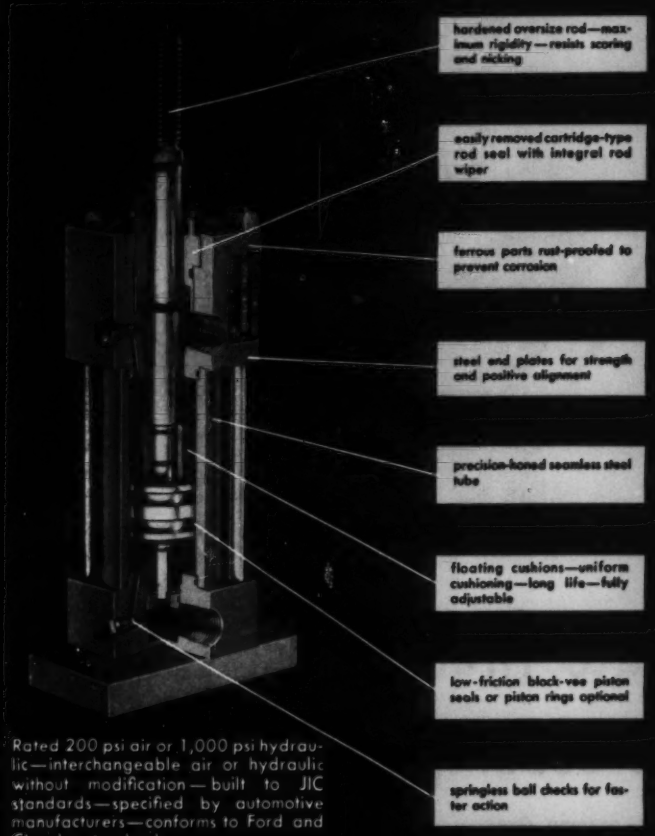
hardened oversize rod—maximum rigidity—resists scoring and nicking
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ferrous parts rust-proofed to prevent corrosion
steel end plates for strength and positive alignment
precision-honed seamless steel tube
floating cushions—uniform cushioning—long life—fully adjustable
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Rated 200 psi air or 1,000 psi hydraulic—interchangeable air or hydraulic without modification—built to JIC standards—specified by automotive manufacturers—conforms to Ford and Chrysler standards.

If your service requirements are severe . . . if you need uniform operation, long trouble-free life, minimum equipment downtime . . . you need S-P *heavy-duty* air and hydraulic cylinders!

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military advisers, have established firm requirements for nuclear-propelled aircraft. The Air Force and AEC both recommended an increase in their own fiscal 1960 budgets for the program to back up these requirements, but have been turned down.

The committee's conclusion: "We have been informed that it is possible to have a flying prototype in the air by the summer or fall of 1962, if a target date is established immediately, and if additional funding is provided now . . . Any other course, in our view, is dangerous to the national security, wasteful of the taxpayers' dollar, and indefensible in the eyes of the American people."

Co-operative Research Called Vital to Small Industry

NEW YORK—Survival of small industry will depend upon creation of co-operative basic research laboratories, according to L. F. Hickernell, president of the American Institute of Electrical Engineers. Citing the high cost of basic industrial research — amounting to between $28,000 and $56,000 per scientist per year— Mr. Hickernell observed, "The time is fast running out when small segments of industry can survive by applied research only.

"On this basis," he said, "the one possibility I see for small industry's survival in the free enterprise system lies in the organization of co-operative basic research laboratories by various branches of industry."

Speaking at the AIEE winter general meeting, Mr. Hickernell also made a plea for the end of duplicated research, which wastes millions of dollars annually. He proposes a "central agency to code scientific and engineering literature and to provide searches on any subject by mechanization." The fast-mounting volume of technical literature is "smothering the profession in its own product," says Mr. Hickernell, and he urges prompt action on the National Defense Education Act of 1958 to fulfill the need for a central science information agency.

Mr. Hickernell suggested that philanthropic institutions give great-

er consideration to the opportunities for beneficial use of funds afforded by the engineering societies. Engineering, he points out, has an outstanding potential of service to humanity and therefore is deserving of financial support.

Meetings

AND EXPOSITIONS

March 19-20—

Society of Automotive Engineers Inc. National Production Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

March 22-25; April 7-10—

Joint Conference on Numerical Control of Machines in Production Processes, presented by the Schools of Engineering and the Div. of Adult Education, Purdue University, and the College of Engineering, University of California, Los Angeles. UCLA program will be held March 22-25 at the University of California Conference Center, Lake Arrowhead, Calif. Purdue program will be April 7-10 at the campus Memorial Center, Lafayette, Ind.

March 23-25—

Third Conference on Manufacturing Automation to be held at Purdue University, Lafayette, Ind. Cosponsors of the conference are the Purdue School of Mechanical Engineering and *Automation* magazine. Additional information is available from the Editor, *Automation,* Penton Bldg., Cleveland 13, Ohio.

March 23-26—

Institute of Radio Engineers. National Convention to be held at the Coliseum and the Waldorf-Astoria Hotel, New York. Further information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

March 31-April 2—

21st American Power Conference to be held at the Hotel Sherman,

Special precision nuts are not "off-the-shelf" items. Whether standard or miniature in size, they require *special* engineering, production facilities and quality controls.

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Circle 421 on Page 19

Large parts, too, can be mass-produced of strong, lightweight

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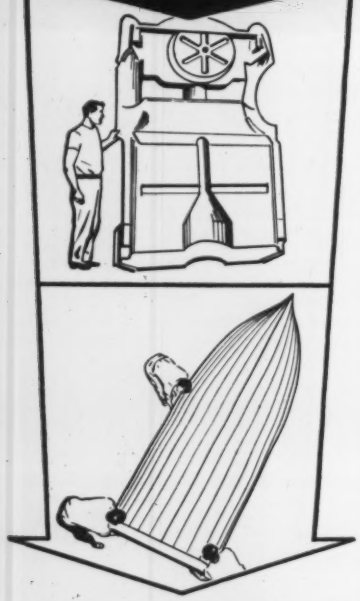


No longer must you use the same old metals for your larger pieces. Now you can modernize your products and spruce up designs with tough, economical MOLDED FIBER GLASS.

Molded Fiber Glass Body Company can custom-mold your big products of strong, lightweight, rust-proof, impact-resistant MOLDED FIBER GLASS, using matched metal dies...

with savings of 50% in tooling time and 80% in tooling costs!

And...MOLDED FIBER GLASS parts can be molded into shapes impossible to make with metals... complex, one-piece, deep-draw parts ... pigmented in any color, or painted.

Molded Fiber Glass Body Company has been successfully mass-producing large parts for the transportation industry for over five years ... gaining experience and production know-how unexcelled anywhere.

What about switching to MOLDED FIBER GLASS for your large products? Write today for free literature and cost estimates.

Molded Fiber Glass Body Company

4629 Benefit Avenue, Ashtabula, Ohio

Chicago. Conference is sponsored by Illinois Institute of Technology, in co-operation with 9 technical societies and 13 other educational institutions. Additional information can be obtained from R. A. Budenholzer, Mechanical Engineering Dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

March 31-April 3—

Society of Automotive Engineers Inc. National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display to be held at Hotel Commodore, New York. Additional information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

April 5-10—

Nuclear Congress to be held at the Public Auditorium, Cleveland. Additional information can be obtained from Engineers Joint Council, 29 W. 39th St., New York 18, N. Y.

April 6-10—

American Welding Society. Annual Welding Show and Convention to be held in Chicago. Technical meetings will be at the Hotel Sherman Monday through Friday; the show will be at the International Amphitheatre Tuesday through Thursday. Further information is available from society headquarters, 33 W. 39th St., New York 18, N. Y.

April 13-17—

American Management Association. National Packaging Exposition and Conference to be held at the International Amphitheatre and the Palmer House, Chicago. Further information is available from AMA headquarters, 1515 Broadway, New York 36, N. Y.

April 13-17—

American Foundrymen's Society. Castings Congress and Engineered Castings Show to be held at Hotels Sherman and Morrison, Chicago. Additional information can be obtained from AFS, Golf and Wolf Roads, Des Plaines, Ill.

April 14-15—

Conference on Industrial Instrumentation and Control to be held at Illinois Institute of Technology, Chicago. Conference is sponsored by Armour Research Foundation in co-operation with the Professional Group on Industrial Electronics of the Institute of Radio Engineers. Further information can be obtained from M. J. Jans, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

April 18-22—

American Society of Tool Engineers. Annual Meeting to be held at the Schroeder Hotel, Milwaukee. Further information can be obtained from society headquarters, 19700 Puritan Ave., Detroit 38, Mich.

April 20-22—

Metal Powder Industries Federation. Fifteenth Annual Meeting and Powder Metallurgy Show to be held at the Sheraton-Cadillac Hotel, Detroit. Further information can be obtained from headquarters of MPIF (formerly Metal Powder Association), 130 W. 42nd St., New York 36, N. Y.

April 25-30—

Scientific Apparatus Makers Association. Annual Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Additional information is available from association headquarters, 20 N. Wacker Dr., Chicago 6, Ill.

"Wow! That's what I call a set of curves!"

Circle 423 on Page 19→

IT'S A MATTER OF

pulling together!

GOODYEAR

And here's how Green Seal V-Belts by Goodyear make pulling together pay—and pay—

On every type of drive—in every part of America—Green Seal by Goodyear are and outlast anything

—AT AN OHIO CHEMICAL PLANT

Operation: Pulverizing nickel formate

Drive: Main drive on micro-atomizer—handles 20 h.p. at 5,868 f.p.m.

Service: *Eight matched V-Belts with the Green Seal served for more than 6 months compared with 4-week life for 10 belts of another make.*

—IN A MISSOURI PIPE PLANT

Operation: Making fire clay and sewer pipes

Drive: 125 h.p. ball-mill drive

Service: *Fourteen matched V-Belts with Green Seal construction served 6 years without maintenance of any kind.*

every kind of industry—in matched V-belts with the pulling together to outperform else belt-users can buy—

—ON A TEXAS OIL RIG

Operation: Drilling oil wells

Drive: Main drive on mud pump

Service: *20 V-Belts with the Green Seal pulled together to drill 202,790 feet of hole—more than 25% better than the average belt-life in this service.*

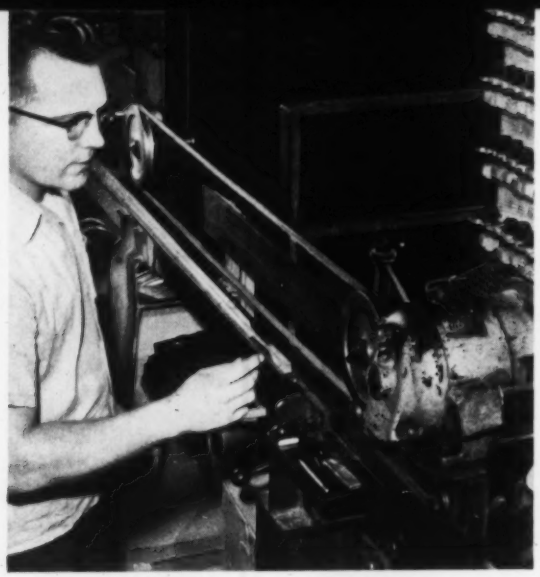
—AT A SOUTH CAROLINA FABRIC MILL

Operation: "Soaping" screen-printed fabrics

Drive: 50 h.p. "soaping" range drive with belt speed of 1,413 f.p.m.

Service: *Ten matched V-Belts with Green Seal construction served 8 years with virtually no time out.*

Here's why **V-BELTS** with the **Green ✿ Seal** always pull together



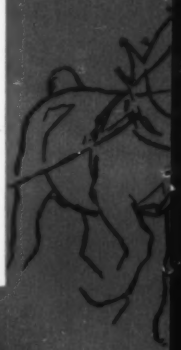
The secret's their unequalled dimensional stability. And it's built into each belt via special tension members of steel cable or exclusive, synthetic Triple-Tempered (3-T) Cord. Then every set is precision-measured—several times over—to make sure they are perfect teammates.

That means matched sets really match. Every belt does its part of the job. There are no "loafers" to put extra strain on the other belts. No belt ever overworks and causes a premature failure. It's strictly a matter of *pulling together* – whether your drive calls for two or fifty belts.

What's more, every V-Belt with the Green Seal is designed to outperform all others. High in modulus, they're low in stretch to minimize take-up. They're friction-balanced – so covers don't stick or grab in the grooves. They're non-dusting, too.

In short, these are the belts that give you maximum, trouble-free hours at minimum cost. You need belts like these to pull together on your drives—large and small.

Just contact your Goodyear Distributor—or fill out the handy coupon below.



Green Seal—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

DIMENSIONALLY STABLE V-BELTS WITH THE GREEN SEAL BY

GOODYEAR

THE GREATEST NAME IN RUBBER

S-51162

THE GOODYEAR TIRE & RUBBER COMPANY, Industrial Products Division, Dept. 794, Akron 16, Ohio
Please send me more information about how V-Belts with the Green Seal solve the major problem in belting multiple V-Belt drives.

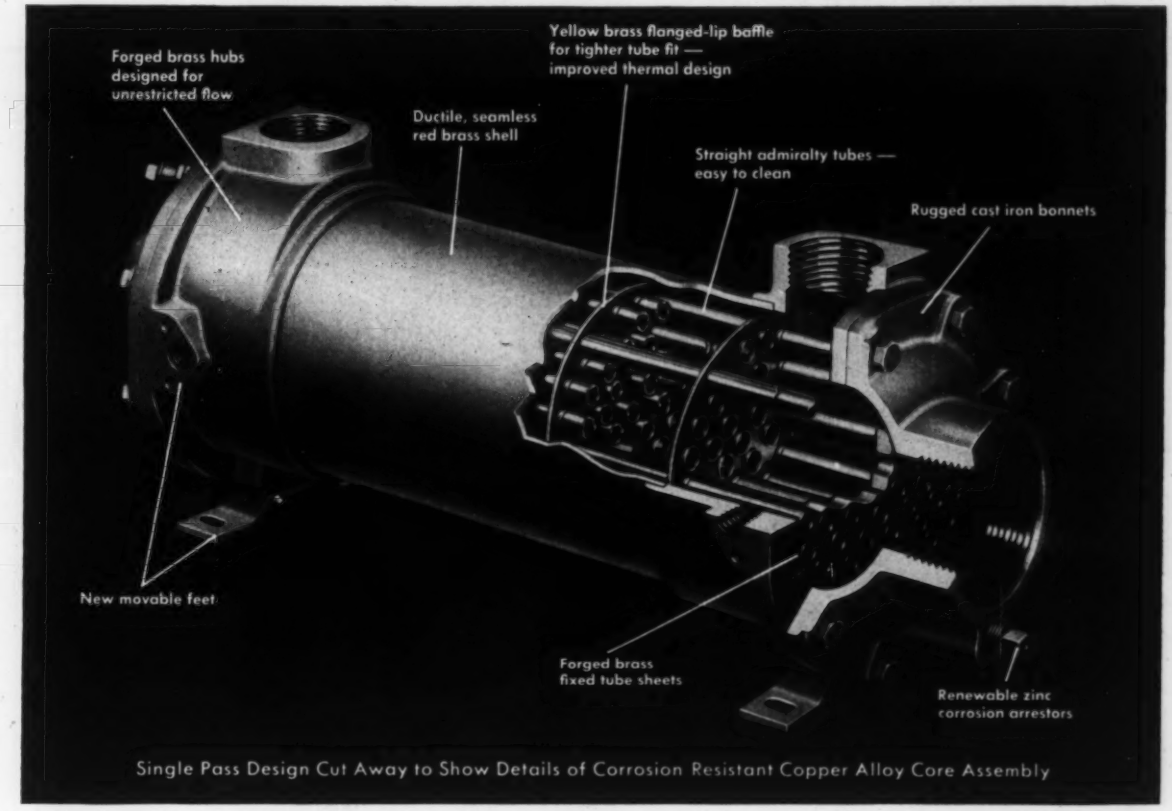
Name .....

Company .....

Street Address ..... City ..... Zone ..... State .....

LOOK AT THE LEADER'S LATEST . . .

New design of a famous line . . . Ross BCF Exchangers


Forged brass hubs designed for unrestricted flow
Yellow brass flanged-lip baffle for tighter tube fit — improved thermal design
Ductile, seamless red brass shell
Straight admiralty tubes — easy to clean
Rugged cast iron bonnets
New movable feet
Forged brass fixed tube sheets
Renewable zinc corrosion arrestors

Single Pass Design Cut Away to Show Details of Corrosion Resistant Copper Alloy Core Assembly

LOOK AT THE LIST . . . new design features, new sizes, new capacities, new mountings, new materials . . . *new low prices!* The leader and originator of small, compact, fully standardized exchangers takes another step forward.

Ross Heat Exchanger (now part of American-Standard* Industrial Division) originated the whole BCF idea 15 years ago. Before then, pre-engineered design, mass produced parts and stocked assemblies were untried for a unit of this type. Designers and users of original equipment were quick to adopt the BCF as standard. Today, on a larger scale than ever, it is cooling lube oil, jacket water, hydraulic and other fluids for a wide variety of industries.

But, even with such success, the BCF has never been permitted to stand still. Ross has persisted in making constant design refinements and performance improvements . . . *the latest are typical: New* baffles with flanged lip at each tube hole and around outer edge for tighter fit and improved thermal characteristics. *New* stamped steel feet, movable in three positions around hubs for easy, more adaptable mounting. *New* sizes and capacities . . . 46 models . . . one, two or four pass designs . . . giving greater selection than ever before.

*American-Standard and Standard ® are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard
INDUSTRIAL DIVISION
AMERICAN BLOWER PRODUCTS • KEWANEE PRODUCTS • ROSS PRODUCTS

Look at the leader's latest. Send in the coupon below for the new Ross Bulletin . . . an up-to-date run down on the new Ross Type BCF Exchanger.

Mail this coupon for new Ross Bulletin

MD3559

To: American-Standard
Industrial Division
Detroit 32, Mich.

Please send, without obligation, your new Bulletin 1.1K6 describing the new Ross Type BCF Heat Exchanger.

NAME _____

TITLE _____

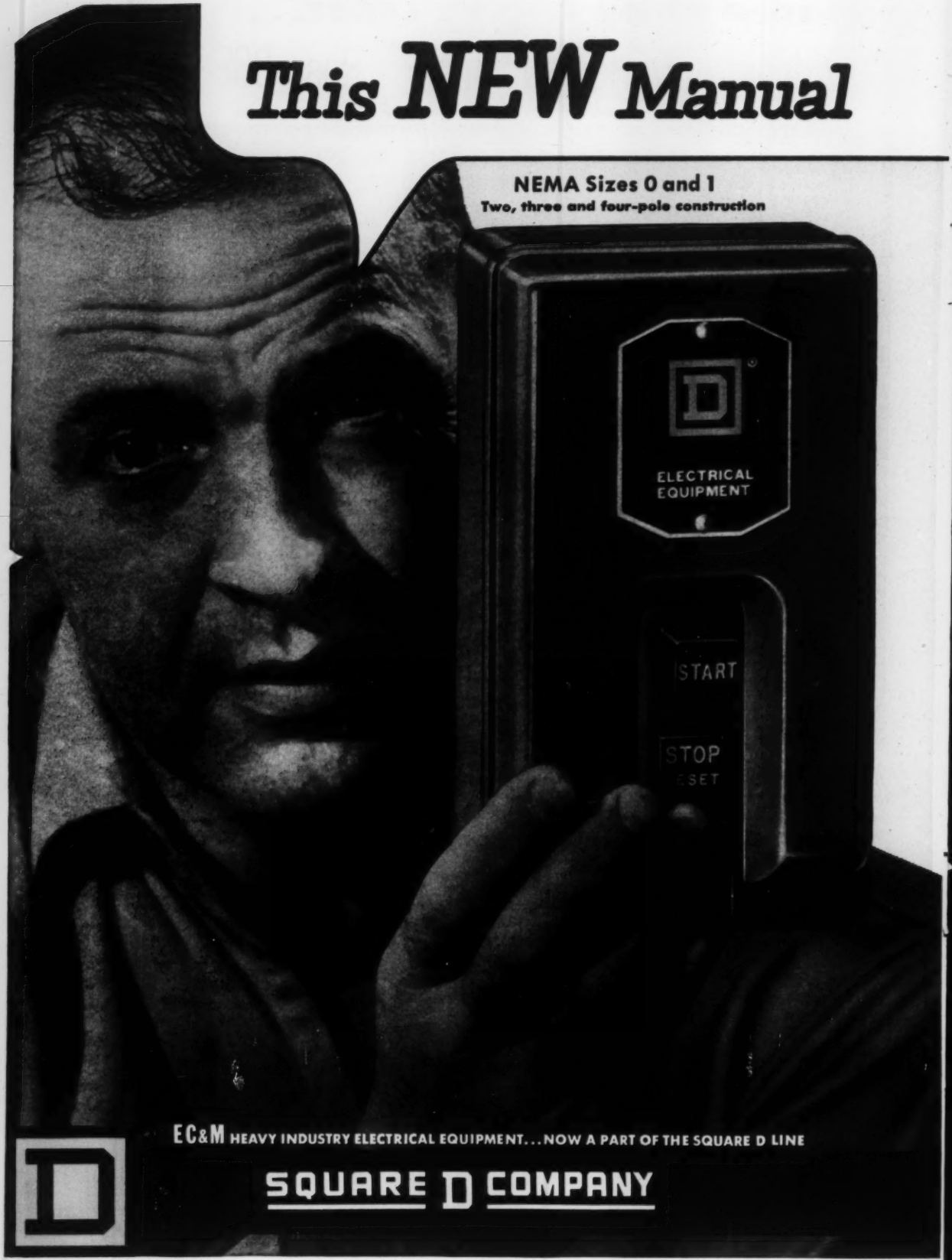
COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

This NEW Manual

NEMA Sizes 0 and 1
Two, three and four-pole construction



EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

Starter has EVERYTHING!

SMALLER!
Takes less space, whether it's built into machine or mounted externally

SMART STYLING!
Matches the streamlined appearance of today's modern machines

QWIK-MAKE, QWIK-BREAK!
Positive snap action opening and closing of contacts. Longer contact life

TRIP-FREE OVERLOAD PROTECTION!
Impossible for operator to hold motor circuit closed against overload

POSITIVE PROTECTION!
Starter will not operate *without* overload units installed

LONGER LIFE!
Toggle Action operating mechanism. Heavy duty construction throughout

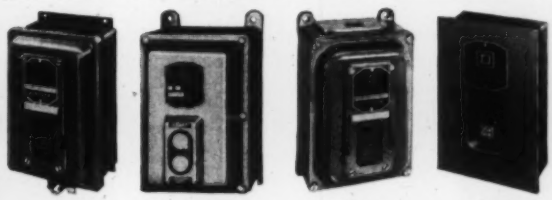
EASIER INSTALLATION!
Wire it without removing starter from enclosure. All terminals have pressure wire connectors

EASIER MAINTENANCE!
"Off-the-Shelf" parts kits make normal maintenance and modifications easier than ever. They're easy to buy, easy to identify, and faster to install

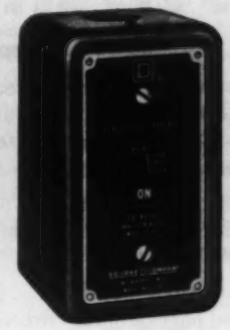
TAMPER-PROOF!
Cover padlocking device prevents tampering by unauthorized personnel. Safety latch locks "start" button in "OFF" position

VISIBLE INDICATION OF OVERLOAD!
Self-centering pushbuttons show when overload has occurred

CHOICE OF ENCLOSURES



NEMA 12 Industrial Use Dust-tight | NEMA 7-9 Hazardous Locations | NEMA 4 Water-tight | Flush Mounting



Fractional-horsepower manual starters are available in a full line of enclosures including General Purpose, Flush Mounting, Water and Dust Tight, and Explosion Proof

Write for BULLETIN 2510 B-C

Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

Circle 425 on Page 19

SEE THE PRINTMASTER 810
AT THE
DESIGN ENGINEERING SHOW
PHILADELPHIA, MAY 25-28

Better Prints . . .

Easier Printmaking . . .

Big, new operating features

The Printmaster 810

Here's the advanced Printmaster 810—with features that outdate every other whiteprinter in its price class. Now you can assure yourself of better whiteprints, more easily, in less time.

1. **More compact—lower in height** . . . saves valuable floor space, allows easier lamp replacement, better control . . . means less fatigue.
2. **New design of brush feed assembly** . . . to automatically control curled edges, folded corners.
3. **New print pick-off** . . . prevents tearing, sticking or scratching.
4. **Improved tracing release** . . . convenient release pedal means immediate control of tracing and print—no loss of time and material.
5. **Cool cylinder design** . . . means practically no sticking in processing plastic-coated materials and foils.
6. **New filtered air system** . . . Fiberglas® filter delivers filtered air—for cleaner machine, cleaner prints—means less shut-down time for cleaning.

And Ozalid offers other great *proven* features such as new steel frame support . . . double paper rods . . . both rear and front delivery . . . and U/L approved safety devices.

Why not test-run your own tracings through the new "810"? Simply call your local Ozalid representative or write: Ozalid, Dept. S-3-5, Johnson City, N. Y.

OZALID®

First Name in Whiteprinting

A Division of General Aniline & Film Corporation
In Canada: Hughes Owens Company, Ltd., Montreal

forging a renaissance in COPPER

THE BETTMANN ARCHIVE

Forging "new metals" has been routine procedure at Wyman-Gordon for 75 years. Contrasting the modern marvels of metallurgical development is the oldest metal employed by man—copper. Here you see the largest copper closed die forging ever produced—a Re-entry Shield weighing 1875 pounds (67-1/2" x 21-1/2"). Unexcelled know-how, with the availability of the most modern forging equipment, assures the ultimate in forging quality to meet the constantly expanding demands of progress—man's quest for greater speeds and power in his unending exploration farther and farther into yesterday's unknown.

WYMAN-GORDON COMPANY

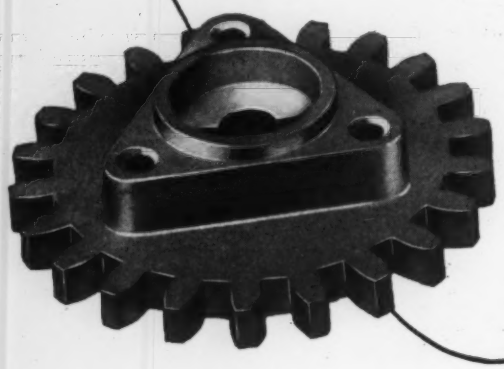
Established 1883

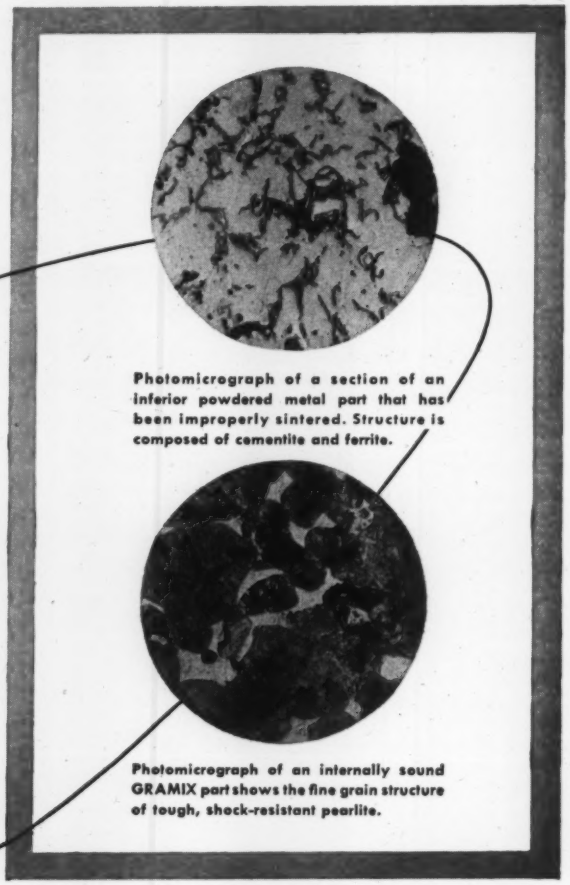
FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM—
Beryllium • Molybdenum • Columbium and other exotic materials

WORCESTER 1, MASSACHUSETTS
HARVEY, ILLINOIS • DETROIT, MICHIGAN

Circle 427 on Page 19

Quality of GRAMIX® powdered metal parts insured by metallurgical control in the laboratory *proven by performance on the job!*



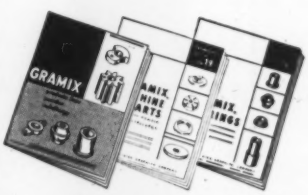


Photomicrograph of a section of an inferior powdered metal part that has been improperly sintered. Structure is composed of cementite and ferrite.

Photomicrograph of an internally sound GRAMIX part shows the fine grain structure of tough, shock-resistant pearlite.

To assure the dependable performance of a GRAMIX powdered metal part in actual operation, the United States Graphite Company combines exacting laboratory tests and rigid production controls to insure the quality of every GRAMIX part. Through the use of the metallograph, for example, GRAMIX engineers can check the internal structure of a part. A comparison of the photomicrographs shown above readily shows the sound under-the-surface quality of a GRAMIX part as opposed to the poor internal composition of an improperly sintered part. In the photomicrograph at the top, notice the cementite between the ferrite grain boundaries. This cementite will tend to break up and rupture under shock. The surface of the material is decarburized and only remnants of pearlite remain. *This condition is due entirely to the lack of adequate sintering control!*

The photomicrograph of the GRAMIX part at the bottom shows a fine grain pearlite structure that's tough, strong and wear resisting. Absolute sintering control along with precise metallurgical control in the laboratory is utilized by The United States Graphite Company to positively assure quality GRAMIX powdered metal parts that will stand up on the job.



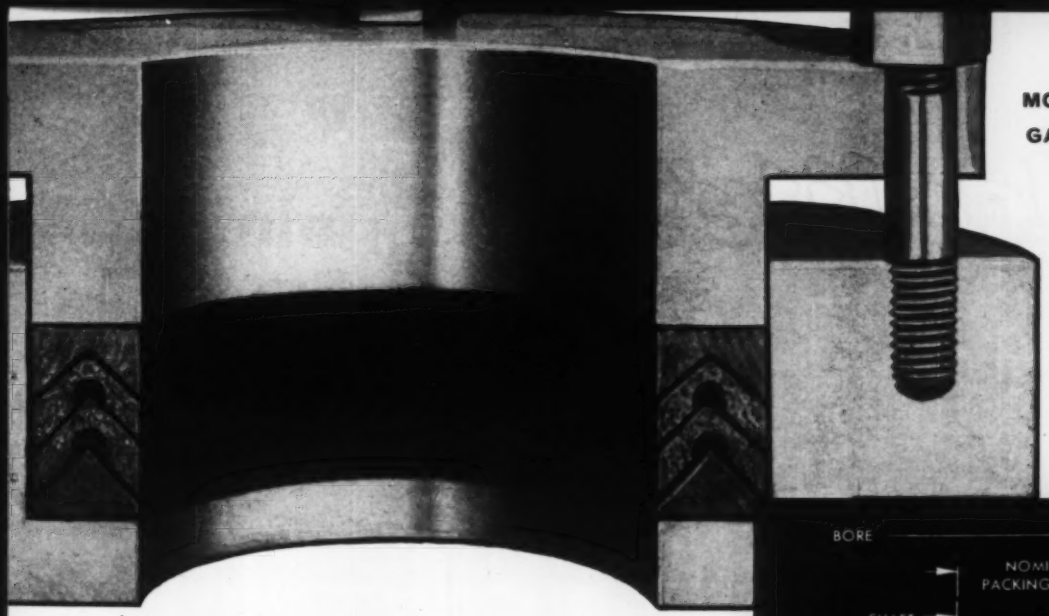
Write today for these helpful engineering manuals. Engineering Bulletin No. 18 covers design and metallurgical requirements and alloy selection of GRAMIX bearings. No. 19 contains facts about GRAMIX Machine Parts and No. 21 contains general information on GRAMIX products from Powder Metallurgy. Get your copies now.

X-264-1

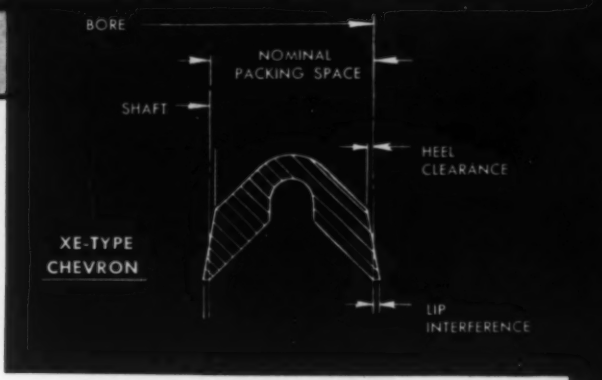
THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



MORE ABOUT THE GARLOCK 2,000



HOW LIP INTERFERENCE AND HEEL CLEARANCE IMPROVE CHEVRON* PACKING DESIGN

There are many reasons why users prefer famous Garlock CHEVRON Packings for sealing rams or rods on hydraulic systems. Design refinements indicated in the drawing above are just two examples:

Heel clearance for easy installation. Experience has shown that unless adequate clearance is provided at the heel of a V-type packing ring it can be very difficult to insert in the stuffing box. The heel clearance on Garlock CHEVRON Rings has proved to be the ideal for easy installation without disturbing the unique advantages of the CHEVRON design.

Lip interference for sealing at low pressures. If the lip of a V-type packing is made exactly to nominal size, and all the clearance taken at the heel, leakage past the lip often occurs at low or zero pressures. On the other hand, too much interference at the lip generates excessive friction resulting in scoring and wear. The lip interference on Garlock CHEVRON Packing is your assurance of minimum friction and positive sealing at all pressures.

There are many other design advantages of Garlock CHEVRON including its hinge-like construction which automatically compensates for pressure changes. If you have a sealing problem involving lubricants, liquids, or solvents at temperatures ranging from −320°F to +600°F, why not find out more about the many forms of Garlock CHEVRON Packings available.

CHEVRON Packings are another important part of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for all your needs. Call your local Garlock representative or write for Folder AD-115.

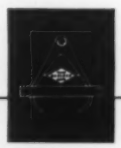
*Registered Trade Mark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U. S. and Canada.

GARLOCK

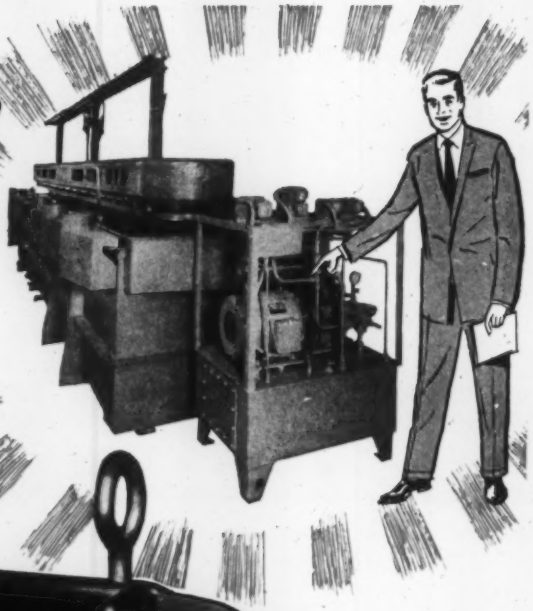
Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products



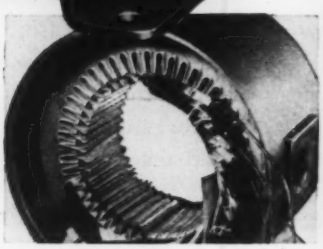
Canadian Division: The Garlock Packing Co. of Canada Ltd.
Plastics Division: United States Gasket Company

Circle 429 on Page 19

Udylite's

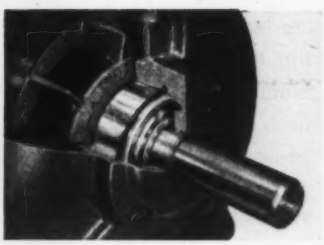


Robbins & Myers
build motors from
1/200 to 200 horsepower



MYLAR* INSULATION INCREASES MOTOR LIFE . . . insures positive insulation. Rag paper backing provides cushioning effect against abrasions and punctures. Entire motor winding is pre-heated, twice dipped in varnish and baked after each dip.

*DuPont registered trademark



BEARINGS POSITIVELY SEALED . . . Double row width ball bearings, sealed on both sides, eliminate frequent re-lubrication. Grease sealed in extra-large reservoirs, resists dust, temperature, humidity and high operating speeds.

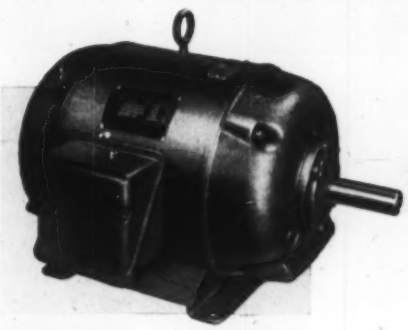
"shining example" shows how...

R&M TOTALLY ENCLOSED FAN COOLED MOTORS BEAT CORROSIVE ATMOSPHERES

Udylite Corporation's famed Automatic Plating Machines put a shine on everything from sewing machine parts to automobile bumpers. R&M Totally Enclosed Fan Cooled Motors power the hydraulic system of these precision machines quietly, smoothly and without vibration. But most important they successfully combat the severe corrosive atmosphere common to all plating operations. R&M Motors are completely protected against this serious motor menace.

Complete R&M motor protection includes careful dipping, baking and painting of all steel parts . . . spraying of rotor and shaft with special rust-inhibitor . . . application of anti-corrosion primer to cast-iron end-heads and terminal box. A cast aluminum fan provides effective cooling by forcing air between enclosed internal and open external shells over motor's entire length. Other important features contributing to long-life protection and vigorous performance are described at left, below.

Robbins & Myers Totally Enclosed Motors range from ½ to 125 hp. Write today for Bulletin 500 MD



OPEN PROTECTED MOTORS . . . R&M open protected motors to 200 horsepower are suitable for many applications formerly requiring totally enclosed construction. Investigate this economical possibility for your application. Write for free Bulletin 520.

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

R&M

let your imagination run wild

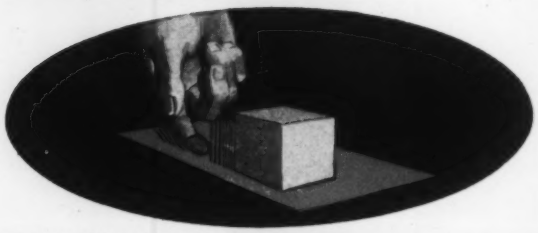
with this coating

EMRALON . . . Acheson's revolutionary new dispersion "opens the door" to a host of "restricted" applications

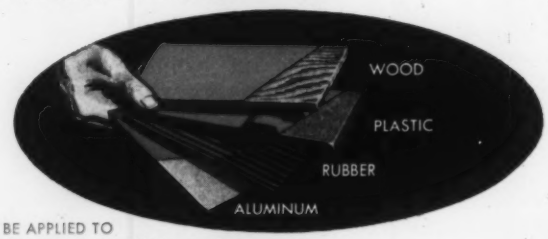
Five years in development, 'EMRALON' surface coatings now make possible the application of Du Pont Tetrafluoroethylene (TFE) to heat sensitive materials such as aluminum, rubber, wood and plastic. Applied by spray, these versatile resin-bonded lubricating films exhibit the low-friction properties of the TFE pigment together with the durability of their specially-selected binders. Thus, hundreds of potential uses which heretofore were impractical because of the high fusing temperature of other processes, can now be reconsidered as workable applications.

First in the Acheson family of TFE dispersions is 'EMRALON' 310,* employing a phenolic binder. Requiring a one-hour cure at only 300°F., it provides an unparalleled combination of low-friction coefficient, toughness, flexibility, adhesion and corrosion resistance. Substrates even more sensitive to temperature, or those where a bake cure is not practical, can be coated with 'EMRALON' 320† air-drying counterpart to 'EMRALON' 310.

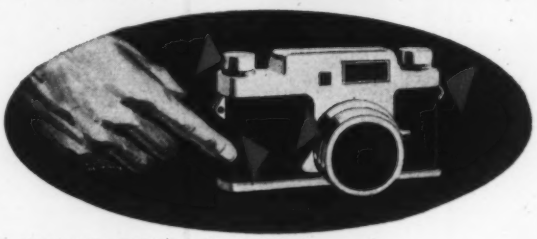
Evaluate 'EMRALON' 310 or 320 in your plant and be among the first to "open the door" to new design possibilities. Send for an introductory package complete with data sheet. Enough to coat 5,000 sq. in. of surface is yours for $4.25 prepaid ($4.50 west of the Rockies). Write today.



LOW COEFFICIENT OF FRICTION



MAY BE APPLIED TO HEAT-SENSITIVE MATERIAL



IDEAL FOR LIGHT LOAD MECHANISMS

Acheson Colloids Company
Port Huron, Michigan

Gentlemen: Your new 'EMRALON' surface coatings suggest themselves as possibilities for a current design problem. Send an introductory package to me promptly.

- ☐ 'EMRALON' 310 (bake type)
- ☐ 'EMRALON' 320 (air-dry)
- ☐ Bill me on Order No._____
- ☐ Check enclosed
- ☐ Please have your service engineer call:

NAME: TITLE:

COMPANY:

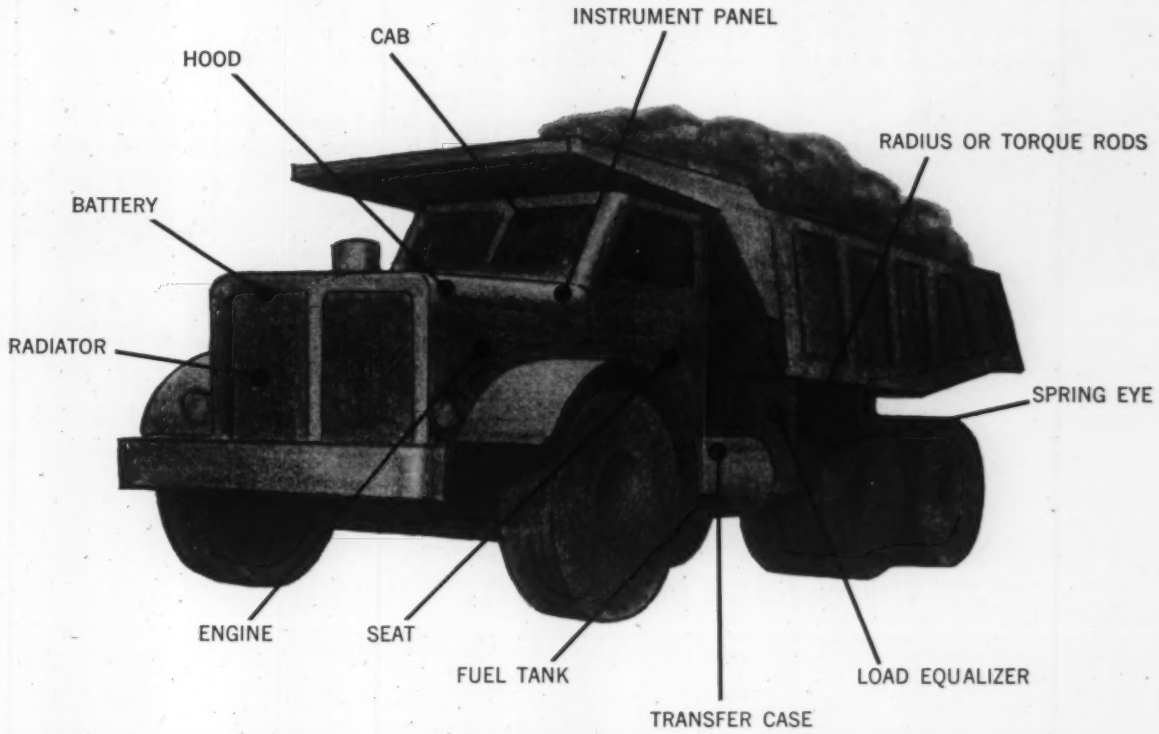
ADDRESS:

CITY: STATE:

APPLICATION:

*'EMRALON' 310 is manufactured under exclusive license from E.I. du Pont de Nemours & Co. (Inc.) under U. S. Patent 2,825,706. Not licensed for use or for sale for use in providing electrical insulation.
†'EMRALON' 320 — Patent applied for

ACHESON *Colloids Company*
PORT HURON, MICHIGAN
A division of Acheson Industries, Inc.
Also Acheson Industries (Europe) Ltd. and affiliates, London, England



critical points for shock and vibration control

Engineered protection against shock and vibration pays off in *better performance*, *longer service life* and *less maintenance*. This is the experience of a growing number of off-highway, construction and farm equipment manufacturers.

By using flexible LORD Mountings and Joints at key points, they eliminate the efficiency-destroying effects of brutal jolts, vibration, distortion and misalignment.

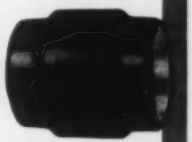
LORD elastomeric units provide positive cushioned action under severe conditions, outlast metal units and never need lubrication. Tough, service-proved flexing elements are specially compounded elastomers, permanently LORD-bonded to steel members. Design is simple and compact, requires no close tolerances, usually fits existing mating parts.

LORD Mountings and Joints are economical, can be specially engineered by LORD to your specific application. Their use eliminates need for "beefing-up" structures, thus permitting increased payloads.

Take advantage of LORD's unsurpassed experience—contact your nearest LORD Field Engineer or the Home Office, Erie, Pa.

Center Bonded Mountings provide flexible support for components, absorb heavy shock loads, isolate vibration and accommodate relative motion without loss of stability. Also feature high unit load capacity and patented rebound protection. Ask for Bulletin 712.

Dynaflex® Joints are long-lasting, lubrication-free bearings or pivots. They accommodate torsional and angular motion, absorb shock and reduce noise and wear. Ask for Bulletin 713.



LORD
BONDED RUBBER

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA · CEdar 7-9247
BOSTON, MASS. · HAncock 6-9135
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DETROIT, MICH. · DIamond 1-4340
KANSAS CITY, MO. · WEstport 1-0138
LOS ANGELES, CAL. · HOllywood 4-7593
NEW YORK, N. Y. · CIrcle 7-3326
PHILADELPHIA, PA. · PEnnypacker 5-3559
SAN FRANCISCO, CAL. · EXbrook 7-6280

"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY · ERIE, PA.

Circle 432 on Page 19

Tailor-made, tough and chemically inert...

. . . these J-M Chempac Teflon components combat chemical and solvent action!*

SMALL OR LARGE . . . intricate or simple . . . J-M Chempac® Teflon components have proved their exceptional resistance to the constant attack of corrosive chemicals in rugged service.

Look to J-M for Teflon packings, gaskets, and moulded shapes made to your exact specifications . . . or for parts that are machined to close dimensional tolerances. Moreover, we can combine Teflon with top quality J-M asbestos to impart the exceptional sealing and heat-resistance properties of the "magic mineral." And in addition to corrosion-resistance, Teflon gives you the advantages of an extremely low coefficient of friction . . . toughness and flexibility . . . and weight-saving possibilities.

You can also obtain J-M Chempac Teflon Packings in moulded and braided types for pumps and valves . . . in a wide range of flange and envelope-type gaskets . . . in rings, cups, sheets and tapes. Your J-M Packings Distributor can supply your needs. Or write Johns-Manville, Box 14, New York 16, New York. In Canada: Port Credit, Ontario.

*TM for DuPont Tetrafluorethylene resin.

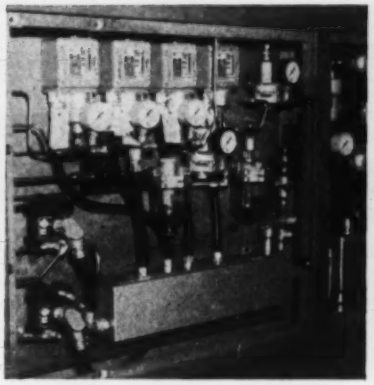
Teflon rods, tubes, tapes and sheets —in addition to components of varied sizes and shapes as indicated here—are also available from Johns-Manville. Prompt delivery of any quantity you need is assured by new J-M production facilities.

JOHNS-MANVILLE JM PRODUCTS

JOHNS-MANVILLE

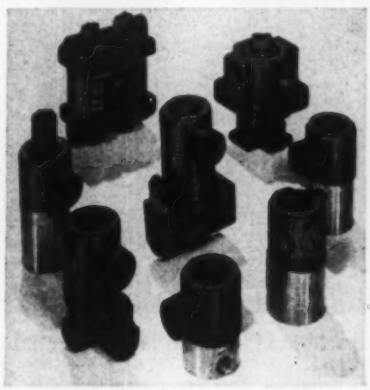
Skinner solenoid valves solve many different cylinder control problems

Application. This Bryant "Centalign" automatic internal grinder is an entirely new concept in precison grinding machinery. Work parts are gravity-fed through chutes and loaded to grind position automatically. Centalign design permits higher, more accurate production at lower cost in the grinding of straight or tapered bores or forms such as ball tracks.

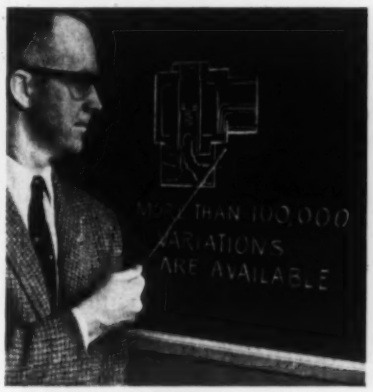


Seven Skinner valves used. Four-way, V9 valves control cylinders actuating work ejector, work interceptor and work loading chute. Others control cylinders for activating a diamond holder for wheel sizing; an oscillator for grinding; and a compensating cylinder to skip wheel dressing action. Still another controls the shop-air supply to the machine.

Adjustable flow features of the four-way valves permit split-second adjustment of cylinder action. And all the valves are small, compact and easy to mount at any angle. Built-in spring returns assure positive closing. Such features enable Bryant to manufacture the Centalign in panels that afford easy access to all pneumatic, hydraulic and electric circuits.



A complete line. There's a Skinner solenoid valve for almost any flow application with a wide variety of media: air, oil, water, inert gases, hydraulic fluids, kerosene and gasoline. Orifice sizes range from 3/64" to 1". Pressure ratings range from 5 psi to 3000 psi. Explosion-proof models are UL approved for Class 1, Group D and Class 2, Groups F and G.



100,000 variations. The Skinner valves used by Bryant are so versatile in design that standard models can be used for applications normally calling for specials. Skinner solenoid valves are engineered to have a life expectancy of millions of trouble-free cycles.

Quality assured. Electrical tests to UL Standards include resistance check of coils in valve; breakdown check of 2x's rated voltage plus 1,000 volts; heat rise check of continuously energized coil for operation not above 85°C (185°F) rise above room temperature. These tests assure that you can use Skinner solenoid valves with confidence.

Skinner solenoid valves are distributed nationally.

For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at Dept. 423.

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

THE SKINNER ELECTRIC VALVE DIVISION • NEW BRITAIN, CONNECTICUT

Circle 434 on Page 19

Memo on Metals

New Age-hardenable Titanium Alloys Offer Up to 220,000 psi Tensile Strength and Easier Formability for 600 to 1,000 F Applications

Three new age-hardenable titanium alloys may prove to be the solution to many of the strength-weight and temperature problems encountered in designing advanced aircraft and missiles. They may also prove extremely economical for such applications.

All three offer much higher strengths than other titanium alloys – and have the light weight and corrosion resistance typical of titanium alloys. Furthermore, they are readily FORMAGEABLE* – capable of being formed in the solution-treated or "soft" condition and then strengthened by simple thermal aging techniques. Each is now in pilot production and available in limited quantities of mill products.

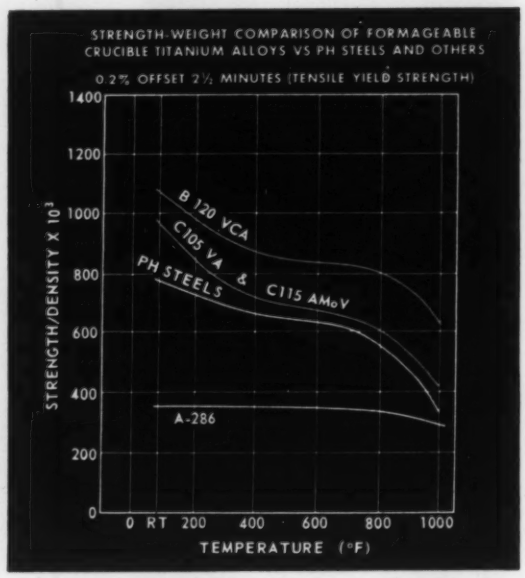
First Age-hardenable All-beta Ti Alloy

Crucible B-120VCA is the first useful titanium alloy with an all-beta (high temperature) structure. It has both the highest strength and best formability of any titanium-base alloy.

This alloy's composition (13%V-11%Cr-3%Al) enables its structure to stay all-beta during forming and/or during slow cooling, and to age to high strength levels at temperatures where distortion is not a problem.

B-120VCA has a unique combination of properties. Room temperature strengths of 200,000 to 250,000 psi have been obtained. On a strength-weight basis this is the highest strength of any available structural material. In short-time elevated temperature tensile tests (1-2 minutes), it offers a decided strength-weight advantage over alternate materials at temperatures up to at least 1,000 F. Under creep conditions, for very long periods of time, it enjoys a strength-weight advantage up to at least 600 F. Beyond this limit, the other Crucible FORMAGEABLE titanium alloys are recommended.

B-120VCA is ductile-weldable, cold-headable, and has great and deep hardenability. Because of this formability, it should prove suitable for applications such as aircraft skins, stiffeners and other primary structural shapes, and for missile pressure tanks, rocket motor cases and structural members. Preliminary tests indicate it may prove unequalled as a construction material for honeycomb assemblies. Because it is so easy to cold-head, it has a large potential in such items as rivets.



Alpha-beta Titanium-base Alloys

Crucible C-105VA is an alph-beta titanium-base material which also is FORMAGEABLE. Its 16% vanadium content stabilizes a sufficient amount of the beta phase for good age-hardenable response; the 2.5% Al content improves the alloy's elevated temperature properties.

C-105VA resolves two conflicting requirements for aircraft sheet material. It is soft, ductile and easily formed in the solution-quenched condition. Because the formed parts can be aged subsequently at moderate temperatures, parts made of C-105VA can possess high strengths at temperatures up to 800 F for long periods of time.

* *age-hardenable titanium alloys*
* *tool steels in production parts*
* *borated stainless steels*

This third alloy, C-115 AMoV (4%Al-3%Mo-1%V), also shows considerable promise for aircraft sheet applications. It is age-hardenable to higher strengths than C-105VA with only slight sacrifice in forming characteristics.

Considerable data on the properties and fabricating qualities of all three alloys have been assembled by Crucible's Titanium Division. For data sheets and additional information, send the coupon.

Tool Steels Replace Standard Alloys for Production Parts

As design and metallurgical engineers require materials with improved properties or greater uniformity, they are turning more to the use of tool steel for production parts. Here are three good examples:

1. Vanes in the hydraulic system that actuates the automatic steering mechanism on cars are made of Crucible REX® M-2 high speed steel. REX M-2 combines the abrasion resistance necessary for minimum wear with the impact resistance needed for long life and safety. The manufacturer experimented with numerous other steels, but high speed steel lasted longer than any other type tested.

2. Actuator bars for a nationally-known calculator are now being produced of Crucible KETOS® – a low-priced AISI Type O1 alloy tool steel – because the thin, close-tolerance contact edges withstood over 4-million high speed blows in a life test. No other steel has lasted more than 1-million cycles before chipping and failing.

3. Cylinder block for a fast acting, aircraft hydraulic pump made of Crucible Chrome tool steel. Pump operates at temperatures up to 500 F, pressures to 5,000 psi. Tool steel was selected over a standard AISI alloy because of its high degree of cleanliness, uniform response to heat treatment, and controlled hardenability. Furthermore, because tool steel practices are employed in making it, the steel more consistently meets the critical mechanical and physical properties required in this application.

For data sheets on these and all other Crucible tool steels – send the coupon.

High Boron Stainless Steels Made Possible by Vacuum Melting

Type 304 stainless steel with boron has proved to be an excellent material for nuclear equipment, because the boron readily absorbs neutrons. By increasing the boron content, valuable weight and thickness reductions can be made in reactor shielding and control rods.

Unfortunately, conventionally melted borated 304 becomes "hot short" – virtually impossible to work if the boron content exceeds 1%. Vacuum melting has provided the answer to this problem. Vacuum-melted 304 stainless is readily workable when the boron content goes up to 2% or even higher.

Vacuum melting the alloy also provides closer control of the composition, because only pure materials are used. So, undesirable elements such as cobalt – which becomes radioactive upon bombardment – can be kept to a minimum. In fact, vacuum-melted Type 304 stainless can be supplied with less than .001% cobalt.

For additional information on vacuum-melted steels – send the coupon.

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EC87, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

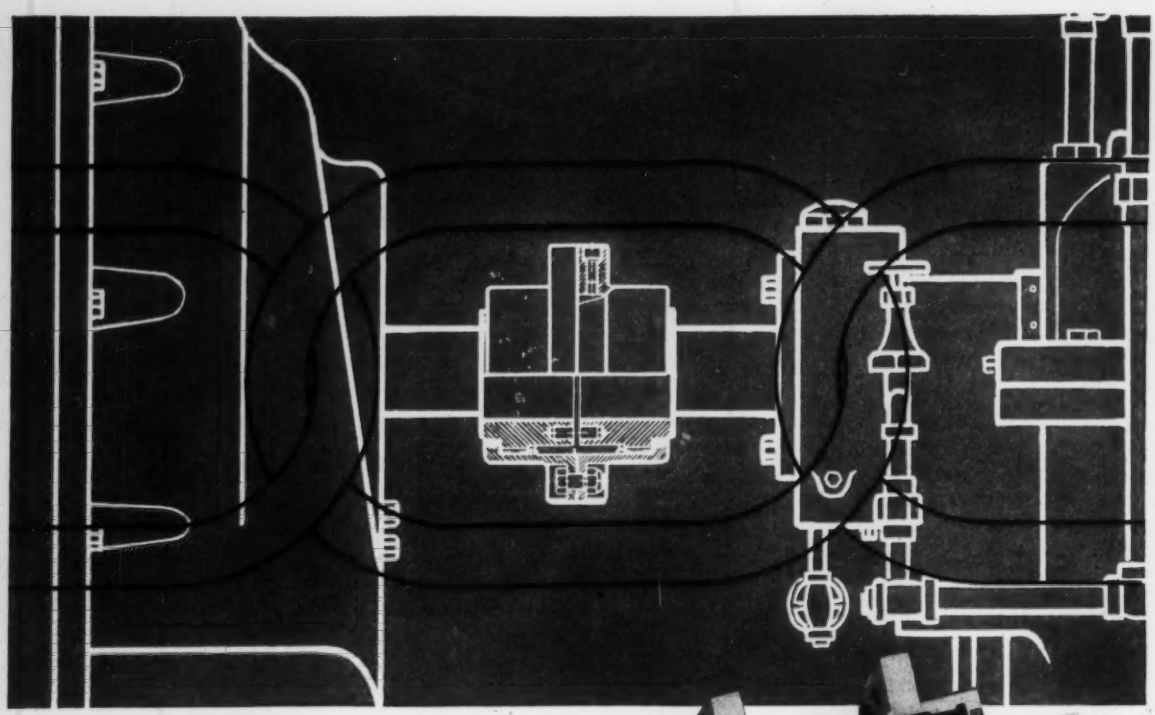
Gentlemen:
Please send me the following:

1. Data sheets on B-120VCA ☐ C-105VA ☐ C-115AMoV ☐
2. A copy of "Titanium Alloys for Aircraft and Spacecraft" by Finlay, Vordahl and Malone ☐
3. Data Book on Crucible tool steels ☐
4. Data sheets on vacuum-melted steels ☐

Name_____ Title_____
Company_____
Street_____
City_____ Zone_____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

*Reg. Trade Mark



FOR WELL-DESIGNED EQUIPMENT...

SPECIFY THIS

POWER LINK

When a lot of time and effort have gone into the design of a piece of driven equipment, it makes sense to pick the power link carefully. Take a pump or compressor, for instance. No matter how well it is designed and built, for long service life and operating efficiency, it needs protection against strains due to misalignment.

Waldron gear couplings provide complete protection and positive, trouble-free drive because

They are strong . . . Hubs and cover sleeves for sizes 1¼A through 7A are machined from tough steel forgings. Hubs are keyed to the shafts. The two one-piece cover sleeves function as a single, rigid unit serving as a floating connecting link between the hubs. High strength of forgings makes possible a very compact coupling with low rotating inertia.

They are reliable . . . There are no flexible parts to bend or break and the coupling is dust, moisture, and oil tight. Patented Walflex seal is at the lowest possible diameter where centrifugal force is least. Clearance between teeth in hubs and sleeve is engineered so that an oil wedge always separates them, taking the wear.

They are available . . . Plenty of rough bore couplings, already assembled—on the shelf for *immediate* delivery. Finish bored standard couplings shipped to meet customers' schedules. We are geared up to give you realistic delivery on *any* type of couplings.

Ask for Catalog 57

JOHN **WALDRON** CORP.

subsidiary of Midland-Ross Corporation

NEW BRUNSWICK, NEW JERSEY

Representatives In Principal Cities
Export Agents—Jacyn Corp., New York, N. Y.

MR

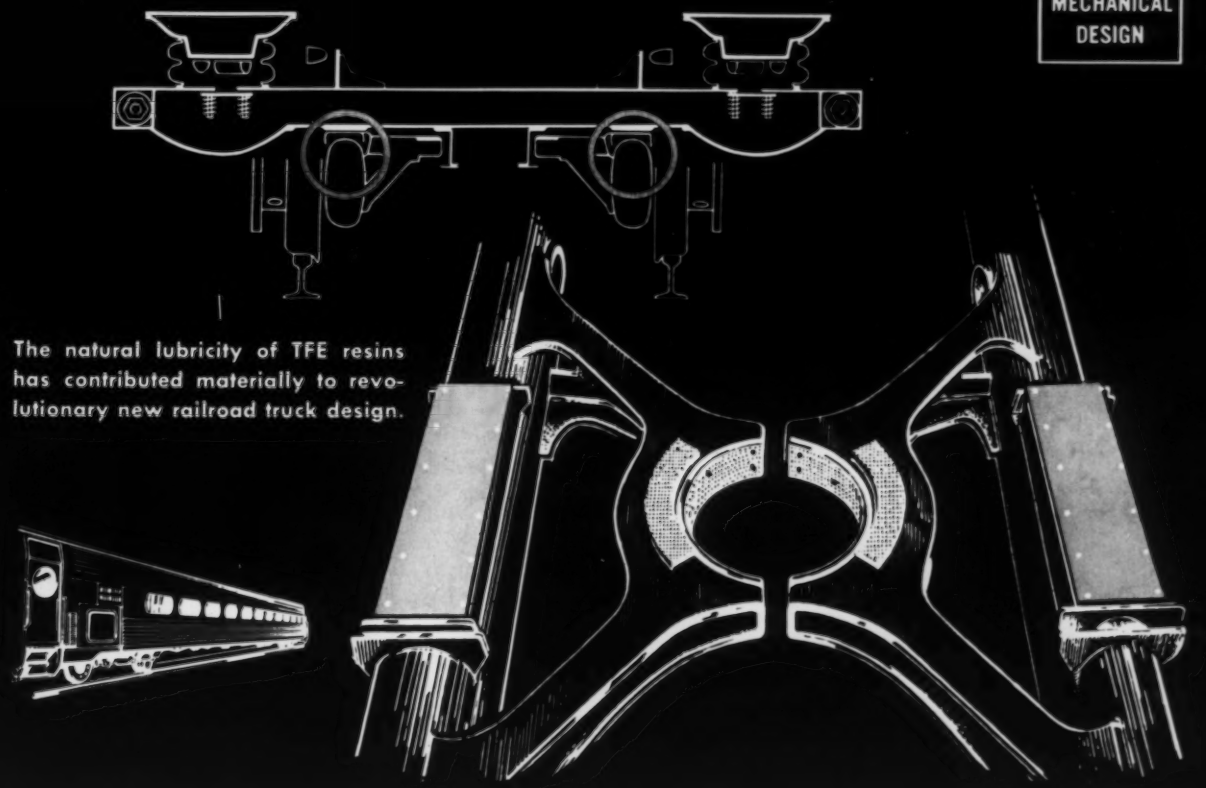
Circle 436 on Page 19

Circle 437 on Page 19→

TEFLON®

FLUOROCARBON RESINS

NUMBER 1
IN A SERIES
MECHANICAL
DESIGN



The natural lubricity of TFE resins has contributed materially to revolutionary new railroad truck design.

Bearings of TEFLON* TFE-fluorocarbon resins eliminate lubrication...resist heat and chemicals

The two bearings of TFE resins on each truck increase the safety of high-speed trains. When trains travel curves at high speeds, centrifugal force carries the center of gravity "off center," loading the side thrust bearings. The low friction of TFE resins permits the truck to steer out of the curve with a minimum tendency to climb the rail.

These bearings have shown no sign of wear in over 120,000 miles of constant use. The next best material could not hold a lubricant and wore out in less than 10,000 miles.

The coefficient of friction of TFE resins is essentially constant over a wide range of loads. Even the best lubricants on metal surfaces rarely give a value for the coefficient of friction as low as the 0.04 which is readily attained with TFE-fluorocarbon resins. TFE resins do not exhibit slip-stick motion, and squeaking and other noises are eliminated.

This unique property of TFE resins has contributed materially to designs such as the new railroad truck above. There is no extrusion under test loads of 22,000 pounds per bearing. At high loads and low velocities, TFE resins have a lower friction than any other solid material, including graphite and molybdenum disulphide. They have significantly lower static friction than the best lubricated metal bushing (as low as 0.016).

*TEFLON *is Du Pont's trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.*

OVER

Where to use bearings of TFE resins

Bearings of TEFLON TFE resins are being used where lubricated bearings are incapable of operation, where there is a possibility of lubricant failure and to attain cost savings.

FOR UNEXCELLED PERFORMANCE—Where slip-stick motion is undesirable or where it is the cause of vibration and noise . . . where the lowest possible static friction is desirable (e.g., reciprocating, oscillating and other systems where static friction is prevalent).

TO AVOID LUBRICANT FAILURES—In low temperature applications (-320°F.), where oils are useless . . . with non-lubricating liquids such as gasoline and solvents . . . at elevated temperatures, where common lubricants degrade or vaporize . . . in low humidity, where dry bearings that depend on moisture cannot be used . . . with heavily loaded, slow-speed bearing surfaces that cannot hold lubricants . . . where wear may occur immediately after each start from rest . . . in areas that are inaccessible or are liable to be overlooked.

TO SAVE MONEY—Near substances which must not be contaminated (textiles, food, etc.) . . . where space and weight savings are essential . . . where bearing replacement costs are high, due to: (1) corrosive substances such as strong acids and alkalies . . . (2) high humidity where there is an increased tendency toward corrosion . . . (3) the danger of fretting or galling . . . (4) oil attracting abrasive dust.

DESIGN CONSIDERATIONS

A. SERVICE LIMITS—Bearing performance can be improved by increasing the mechanical properties and thermal conductivity of the TFE resin construction. This can be done with the use of additives or reinforcements such as glass, graphite or metal or by using woven fabric of TEFLON fiber.

These bearings can be tailored to meet your specific requirements of load and velocity. The common PV (pressure times velocity) relationship does not apply over the useful range of TFE resins because the friction varies with the load. Therefore, maximum service limits cannot be expressed as PV alone. The following table provides an indication of the capabilities of the various types of bearings:

UPPER SERVICE LIMITS OF VARIOUS CONSTRUCTIONS*

MATERIAL	LOAD (psi) 2 ft. per minute velocity	VELOCITY (ft./min.) 100 psi load
Unmodified TFE resins	1,000	100
Compounded TFE resins	3,000	200
Metal-reinforced TFE resins	40,000	1,000
Fabric of oriented fibers of TFE resins	60,000	200

*These are values for unlubricated service. With water, acid or oil lubrication substantially higher velocities can be obtained.

B. LUBRICATION—Frequently bearings made of TFE resins are used in lubricated service to reduce starting friction and wear, or in applications where lubrication may be temporarily stopped or overlooked.

In lubricated service the flexibility of TFE resins permits the bearing face to conform to the shaft so that the oil flow required for hydrodynamic lubrication is reduced by several orders of magnitude.

C. STARTING FRICTION—In some bearing applications the starting friction is important. It may either control the efficiency of the equipment or determine the power requirements necessary. The lower coefficient of static friction offered by bearings of TFE resins can often help solve these problems and result in considerable cost savings.

Even at low loads (50 lb.), where starting friction is less of a problem, bearings of TFE resins exhibit static coefficients of 25-70% less than other common bearing materials. It is at high loads, however, that these bearings show their greatest superiority.

This table shows a comparison of the static friction of various flat bearing materials both dry and lubricated.

STATIC COEFFICIENTS OF FRICTION†
TIME AT REST 1 MINUTE

	Ground Cast Iron 20 micro. in. (RMS) 50 lb.	Scraped Cast Iron 20 contact points/sq. in. 50 lb.	Ground Steel 20 micro. in. (RMS) 50 lb.
Glass-Filled TFE resins	DRY 0.148	0.091	0.140
	LUB 0.090	0.094	0.095
TFE resins	DRY 0.079	0.070	0.087
	LUB 0.046	0.098	0.079
Graphite-Filled TFE resins	DRY 0.076	0.130	0.110
	LUB 0.075	0.084	0.087
Bearing Bronze	DRY 0.260	0.250	**
	LUB 0.150	0.211	0.098
Cast Iron	DRY 0.350	0.202	**
	LUB 0.142	0.30	0.123

†Coefficients of friction of flat sliders. By: E. J. Weiter, A. O. Schmidt. Presented at the ASME Semi-Annual meeting—June, 1957.

**Denotes increasing coefficient on successive tests.

SEND FOR MORE INFORMATION

Further details on the design of bearings of TFE-fluorocarbon resins may be obtained from your local supplier . . . look for him under "Plastics—Du Pont" in the Yellow Pages. Supplementary engineering data on the frictional properties of TFE resins and on filled resins will be sent to you on request. Ask your supplier or write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Rm. T-25-3-5 Du Pont Building, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec

DU PONT

REG. U.S. PAT. OFF.

TEFLON®

FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Rockwell-Standard and J. I. Case Work Together to Design Custom Drive For The New "1000" Combine

When engineers from the J. I. Case Company designed this big-capacity, self-propelled combine—they aimed at new high standards of performance. Specifications called for a special drive, as well as other special components.

That's when the J. I. Case Company brought the drive specifications to Rockwell-Standard Corporation engineers. Here, experienced axle engineers studied the needs . . . and produced a specially designed Timken-Detroit® drive that met *all* the J. I. Case specifications. A drive that *really* puts power to work.

Once again, Rockwell-Standard proved it is more economical for builders of special equipment to draw on specialists for their special needs.

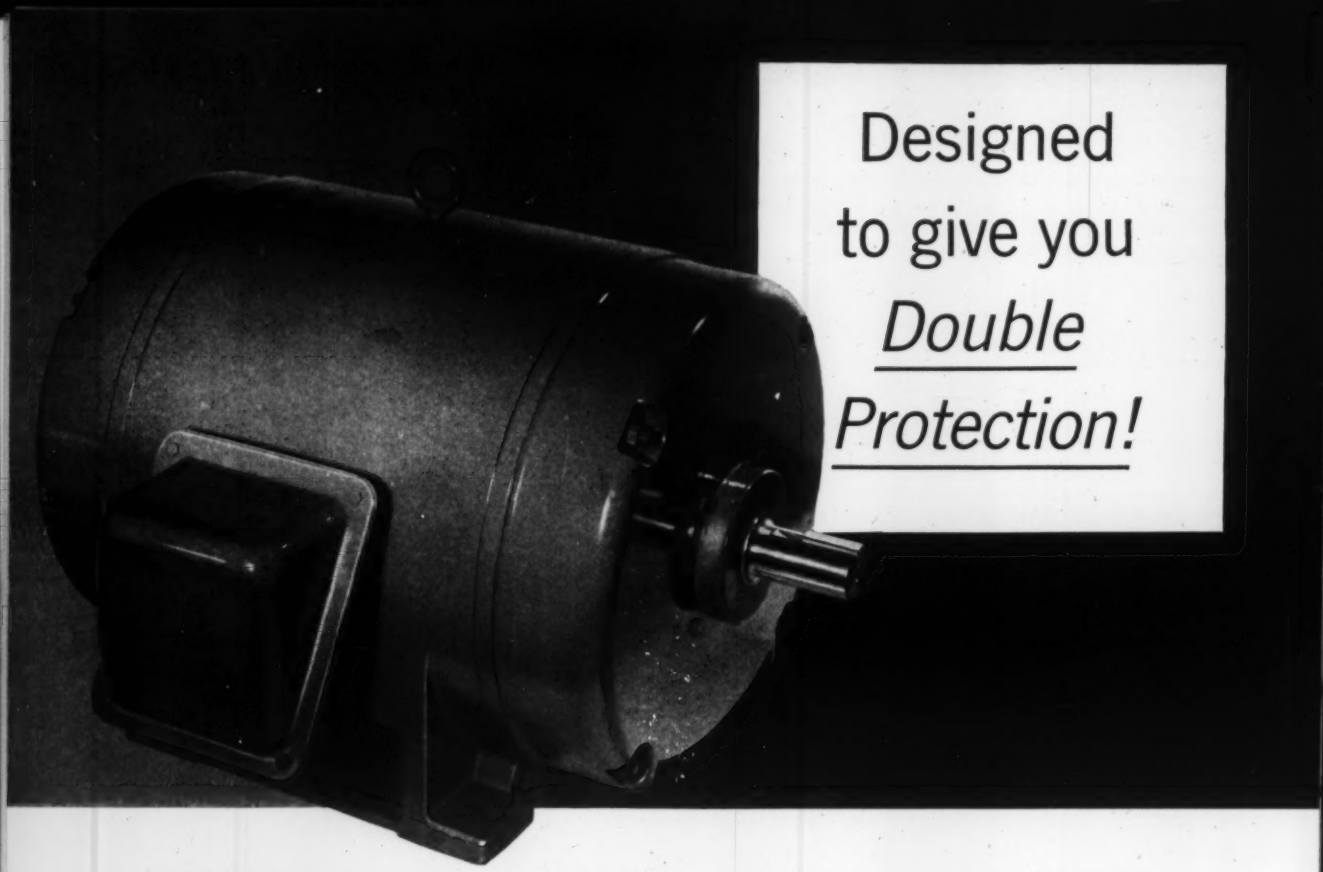
If you have a problem in designing or building self-propelled drives, call in Rockwell-Standard axle engineers. It costs you nothing, and will undoubtedly prove very helpful in saving you both time and money.

TIMKEN Detroit AXLES
ROCKWELL-STANDARD CORPORATION

© 1959, R-S Corporation

Plants at: Detroit, Michigan • Oshkosh, Wisconsin
Kenton and Newark, Ohio • New Castle, Pa.

ANOTHER PRODUCT OF **ROCKWELL-STANDARD** CORPORATION



Designed to give you *Double Protection!*

WAGNER TYPE DP MOTORS

PROTECTED against corrosion...

PROTECTED against splashing liquids...

WM59-9

Wagner Type DP Motors provide *double protection* that means longer life—more versatility of application. Rugged cast iron frames and endplates are highly resistant to corrosion. Dripproof enclosures are so well designed that these motors can handle many applications that formerly required splashproof motors. These motors pack ample power into little space, are light in weight and are easy to maintain.

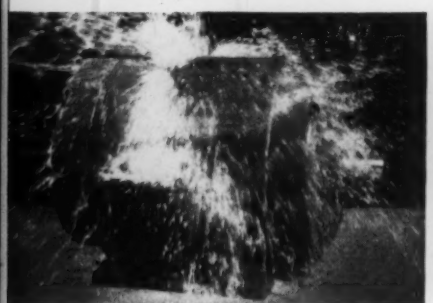
SLEEVE BEARING MODELS AVAILABLE. The entire line of ratings is available with ball bearing construction, or with steel-backed, babbitt-lined sleeve bearings of high load carrying capacity that provide quieter operation.

Let a Wagner Sales Engineer show you how these motors can be applied to your needs. Call the nearest branch office or write for Wagner Bulletin MU-223.

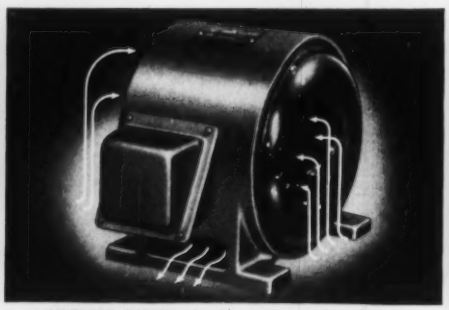
Branches and Distributors in All Principal Cities

Wagner Electric Corporation

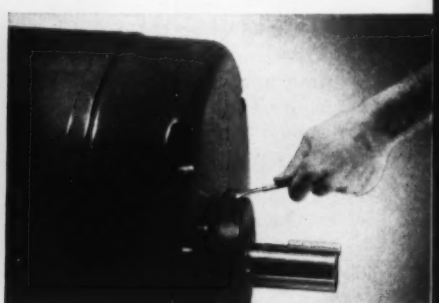
6404 Plymouth Ave. • St. Louis 14, Missouri



DOUBLY PROTECTED—Air intakes and outlets are positioned to provide complete protection against dripping or splashing liquids. Rugged cast iron frames protect against rough handling and corrosion.



COOLING RUNNING—Specially designed baffles, which protect the stator windings, direct a cooling stream of air through the motor to effectively cool the motor—add to motor life.

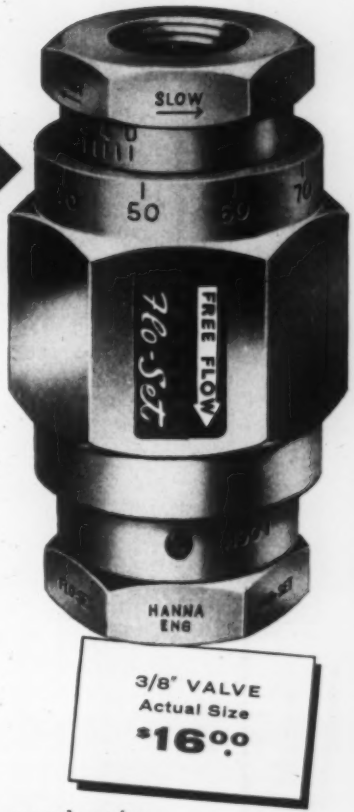


CAN BE RE-LUBRICATED—Original factory lubrication will last for years in normal service—but grease plugs are provided to permit re-lubrication that adds years to motor life under severe conditions.

Circle 439 on Page 19

NEW HYDRAULIC FLOW CONTROL VALVE

Calibrated for Precision Control



HANNA *Flo-Set 1000* VALVES

are used for controlling flow of petroleum liquids, water and synthetic hydraulic fluids.

Pressure to 1000 psi.

Sizes ¼", ⅜", ½" and ¾"

Temperatures –40° F to +250° F

To meet the demands for precision control of hydraulically powered equipment, Hanna offers this new calibrated speed control valve. Flow can be accurately regulated from zero to desired rate by turning the adjusting sleeve. Once set to the desired flow rate the valve can be "locked". Calibrations assist in setting the valve to pre-determined flow rates.

The new Flo-Set 1000 Valves are the result of over 50 years of Hanna design and manufacturing experience in the field of fluid power. They are built to close tolerances with quality materials and like all Hanna products they are offered only after extensive laboratory testing and field experience. Their performance is guaranteed for the service specified.

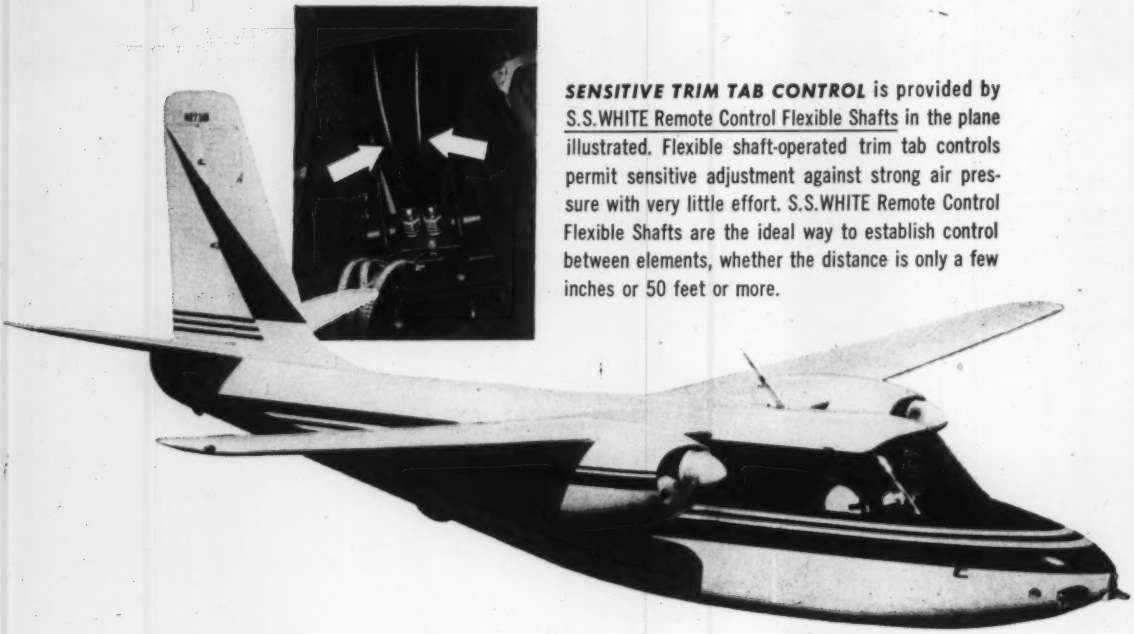
Ask your Hanna Representative listed in your classified directory and Thomas' Register for complete information—or write us for details.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

1751 Elston Avenue • Chicago 22, Illinois

Circle 440 on Page 19

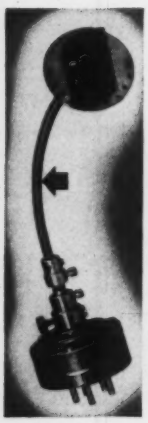


SENSITIVE TRIM TAB CONTROL is provided by S.S.WHITE Remote Control Flexible Shafts in the plane illustrated. Flexible shaft-operated trim tab controls permit sensitive adjustment against strong air pressure with very little effort. S.S.WHITE Remote Control Flexible Shafts are the ideal way to establish control between elements, whether the distance is only a few inches or 50 feet or more.

S.S.White

CONTROL AND DRIVE IDEAS FOR ENGINEERS

Tips on Better Designing with Flexible Shafts



FLEXIBLE COUPLING SHAFT eliminates need for alignment and does not transmit vibration in this variable frequency crystal holder. The coupling shaft is connected to the crystal holder and also to the dial with a set screw, making it easy to assemble the shaft after holder and dial are mounted. S.S.WHITE Coupling Shafts are available for either remote control or power drive.

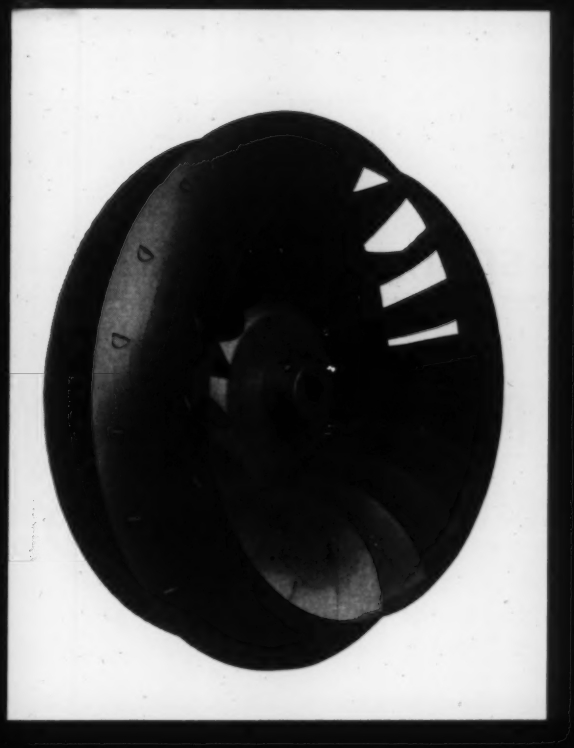
LIGHTER WEIGHT AND SIMPLER DESIGN are achieved in this brush cutter by the use of an S.S.WHITE Power Drive Flexible Shaft. Cumbersome and troublesome gears are eliminated. Better balance is gained, since the weight of the motor, carried by the operator's harness, is located to give the unit perfect balance for finger-tip control. The unit can be swung easily into any position, high or low. The flexible shaft gives fully dependable service.

WHETHER YOU NEED specially engineered, custom flexible shafts, or standard off-the-shelf shafts, rely on S.S.WHITE. For information on standard shafts, write for Bulletin 5801; for custom-designed shafts, ask for Bulletin 5601.

S.S.White — IN FLEXIBLE SHAFTS

S.S.WHITE INDUSTRIAL DIVISION, 10 East 40th Street, New York 16, New York
Western Office: 1839 West Pico Blvd., Los Angeles, Calif. (Dept. 4)

Circle 441 on Page 19



TORRINGTON CRACKS THE NOISE PROBLEM The squeeze toward compactness in room air conditioners has forced the decibel level up to the point that *noise is now the No. 1 problem.* ▌ In anticipation of this trend, two years ago Torrington's air impeller laboratories went to work on "noise." ▌ The result is the revolutionary Torrington H Wheel—one of the most important breakthroughs in air conditioning history. ▌ In one room air conditioner application test the H Wheel reduced the noise level from 63 to 53 decibels; and it was less than *one half as loud.* ▌ Torrington's engineering department is now offering samples of the H-Series Wheel for evaluation in your new product development program.

THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

1/2

Circle 442 on Page 19

Can a better spring save you money?

. . . then put American Spring Engineering Research Service to work for you!

WOULD you like the springs you now use to last longer? Would you like to cut their cost? Do you need design assistance on a difficult new spring application? *American Steel & Wire may be able to help you.*

We maintain complete spring testing facilities to help you solve any spring problem. Our spring engineering specialists can help you improve the *design* of your spring. We can help you determine the best possible *steel* to use. Then, we can completely check spring performance. We can simulate any spring operating condition and verify these recommendations in terms of improved service in your product.

Hundreds of companies have taken advantage of this service and have profited from it. Why don't you? Just write American Steel & Wire, 614 Superior Avenue, N. W., Cleveland 13, Ohio.

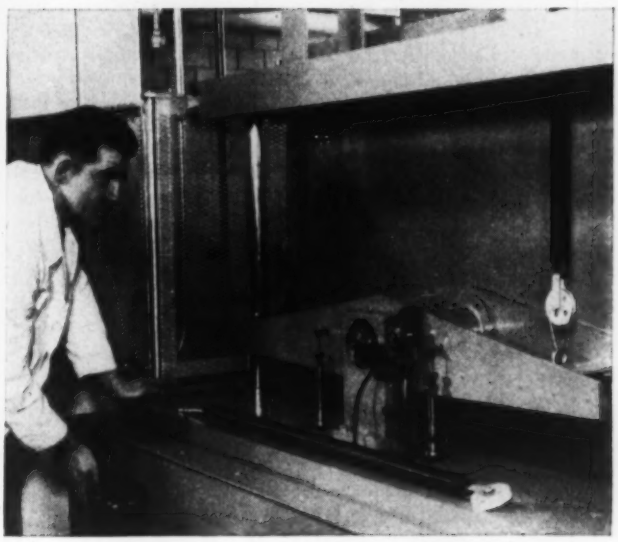
USS is a registered trademark

Heavy-Duty Clutch Springs Last Longer Now—Thanks to AS&W Spring Research!

The Lipe-Rollway Clutch Division, Lipe-Rollway Corporation, Syracuse, New York, asked AS&W Spring Engineering Research Service to determine if design change would lengthen the life of the flat wire compression springs used in their clutches. AS&W recommended design changes that greatly increased the spring life.

AS&W Spring Tests Make Possible New Design Rocking Chair!

40,000 springs—not one failure—American Steel & Wire helped Homecrest Company, Wadena, Minnesota, design a round wire helical torsion spring for an unusual new type of swivel rocking chair. To date, 20,000 of these chairs have been sold, but not one failure of the 40,000 springs has been reported.



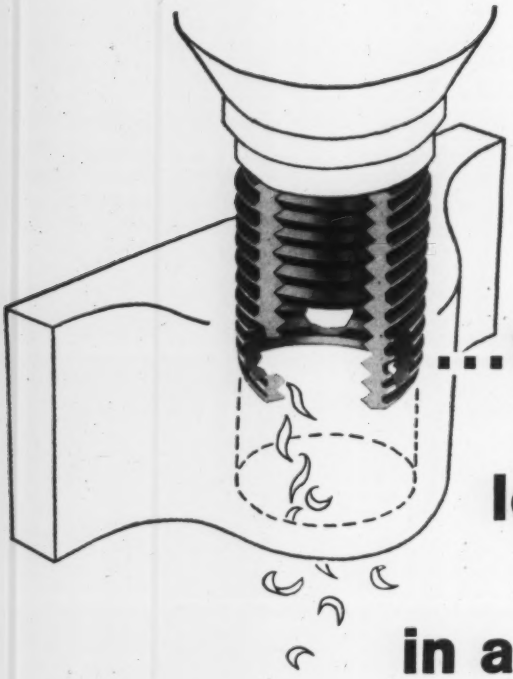
Design Change Increases Operating Life of Garage Door Springs!

The Steel Door Corporation, Birmingham, Mich., asked the AS&W Spring Engineering Research Service for a statistical evaluation of the fatigue life of this extension hook-type spring. As a result of the test, AS&W recommended a design change which has materially lengthened the operating life of the spring.

American Steel & Wire Division of USS United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

Circle 443 on Page 19



The TAP-LOK® threaded insert ...taps its own thread locks itself in... in a single operation!

TAP-LOK inserts provide strong wear-resistant threads in relatively soft machinable materials (wood, plastic, aluminum, etc.) . . . as well as in *harder* materials where repeated assembly makes excessive thread wear a problem.

Unlike ordinary threaded inserts, however, TAP-LOK inserts cut their own threads in the parent material. Thus, *no additional assembly time is required* with a TAP-LOK insert.

Its installed cost is the lowest of any threaded insert.

The locking action is achieved in this way: the tapered pilot section carrying the thread cutting edges is followed by the full diameter threads which force their way into the parent material. Once installed, a TAP-LOK insert is permanently locked in place.

Available in the types shown below, TAP-LOK inserts can be used wherever threaded inserts are required. Write today for complete information.

Slotted:—Full V-form external threads provide maximum locking torque; permit wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings, plastics. Class 2B internal thread — MIL-MS 35914.

H-Series:— A heavy walled insert with truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.

W-Series:—Coarse-pitch external thread offers maximum strength; permits installation in small wooden sections without splitting. For furniture, cabinets and other wooden parts where strong, permanent threads are required.

P-Series:—This Tap-Lok insert was designed to eliminate thread wear and renew damaged threads in spark plug sockets in aluminum cylinder heads. It is available from stock for standard plug sizes to meet most needs.

TAP-LOK

Another fastener development from—

GROOV-PIN CORPORATION

1130 Hendricks Causeway, Ridgefield, N. J.

Circle 444 on Page 19

Hydraulic Cylinder Manufacturer Specifies

Loading a minimum quantity of Ostuco tubing at the Shelby mill — in this instance only 150 feet.

"When you make hydraulic cylinders in 11 bore sizes . . . dozens of different pressure ratings . . . a variety of wall thicknesses and analyses — you've got a man-size tubing inventory problem.

"That's why we switched to Ostuco tubing made to our *exact specifications*. We like its availability in truly *small minimum quantities*. And with its consistently close tolerances, shipment after shipment, Ostuco tubing has *cut our machining time over 50 percent* . . ."

This is an actual case history of a manufacturer with a severe inventory problem. He required special tubing grades in minimum quantities. If you're faced with a similar situation, it's time you contacted your Ohio Seamless representative, listed in the Yellow Pages, or the mill at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

AA-5843

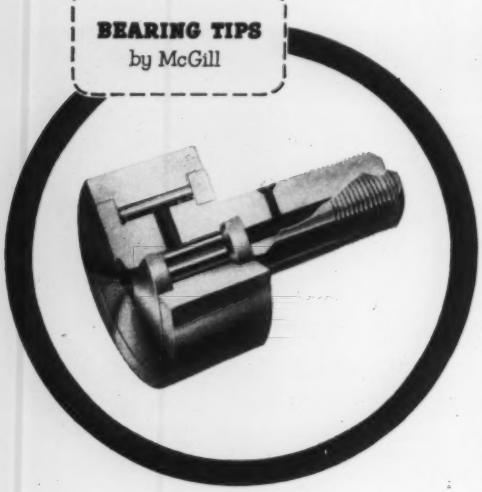
OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company · SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, St. Petersburgh, Salt Lake City, Seattle, Tulsa, Wichita CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

BEARING TIPS
by McGill



McGILL *CAMROL*® bearings cost less to increase efficiency of cam follower, guide and support roller applications

Using CAMROL CF and CYR (cam yoke roller) bearings eliminates the inconvenience of obtaining and processing component parts for built up followers. It costs less to select the proper size CAMROL bearing from stock than machine and assemble loose bolts, bushings, bearings, and snap rings.

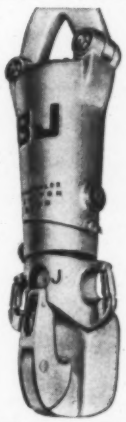
CAMROL bearings are engineered and precision built to carry heavier loads with greater accuracy and alignment. An extra heavy outer race with full roller complement on a flanged stud (or inner for CYR) offers high load and shock capacity. Smooth, dependable action with low starting friction is assured through longer machine life. Available sealed also.

Improved performance, reduced friction and greater accuracy as ram guides in huge welder

The long ram stroke and large diameter welding wheel impose severe requirements on the CAMROL equipped ram guiding device of this resistance seam welder manufactured by the TAYLOR-WINFIELD CORPORATION.

The CAMROLS provide greater accuracy with less friction than was experienced with a round ram and bushing type bearing formerly used. Lubrication is simplified, maintenance reduced and performance is excellent.

The welder has a throat depth of 84" and a 12" vertical stroke of the upper ram carrying the large diameter welding wheel.

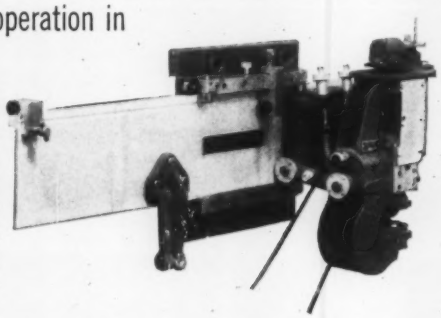


CAMROL® bearings take severe impact loads in hydraulic snubbing hooks

CAMROL CF bearings are used as hook positioner rollers in BYRON JACKSON HYDRAPLEX HOOKS. These heavy-duty (500-ton capacity) hooks are used in oil well drilling work. The hook positioner mechanism includes CAMROL cam followers that travel on a hardened cam track when the load is released to return the hook to its original position. The CAMROL bearings take severe impact loads in the thousands of pounds.

Ease of assembly and smooth operation in electrolimit continuous gage

PRATT & WHITNEY CO., INC., manufacturers of the ELECTROLIMIT CONTINUOUS GAGE shown here have cut costs through the elimination of built up followers requiring ball bearings, shafts, spacers and milling slots by using sealed CAMROL bearings. They are prelubricated and protected. The CAMROL bearings which travel along a vertical cross slide rail, provide smooth, easy action as the gage slides onto strip material running through the mill. No bearing replacement reported in over 10 years.



engineered electrical products

McGILL®

precision needle roller bearings

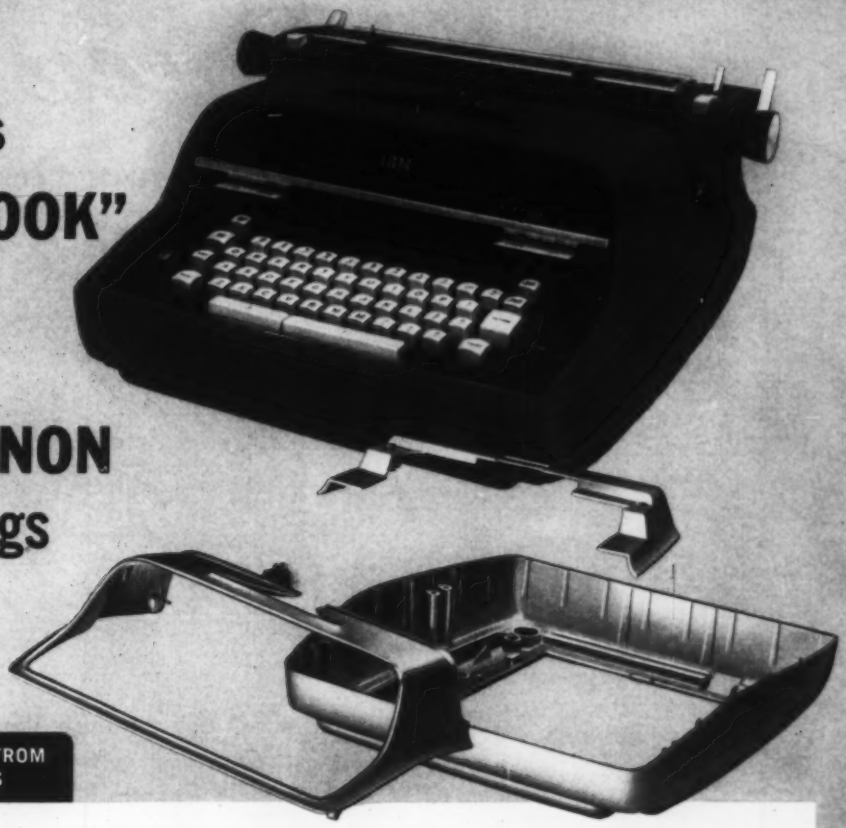
SEND FOR CATALOG No. 52-A

MULTIROL — GUIDEROL — CAMROL

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 446 on Page 19

IBM®'s "NEW LOOK" enhanced with MT. VERNON Die Castings



CASE HISTORIES FROM MT. VERNON FILES

Behind the sleek silhouette of the dramatically new IBM electric typewriters is "more than a quarter of a century of experience . . . a combination of styling and engineering advances" that promise — and deliver — better performance and easier typing.

For its enclosure IBM knew what it wanted: a new high in eye-pleasing design combined with the many low cost, production benefits of die-casting. It was only natural that, for these die castings, once again, they turned to Mt. Vernon, a reliable supplier to IBM for over 25 years.

And, once again, they found Mt. Vernon's co-ordinated four-fold service — designing, die making, casting, and machining—equal to the job of meeting their strict requirements: strong, gracefully arched, thin-walled, large aluminum sections that match and fit perfectly. The three castings that cradle and enclose the intricate typewriter mechanism are delivered completely machined, ready for finishing.

Like IBM, leading manufacturers in all industries know and rely on Mt. Vernon's experienced use of its complete facilities for die cast zinc and aluminum parts ready for assembly. These services, all under one roof in 200,000 square feet of space, may hold the answer to your design and production problems. Think about it . . . and let us know. We'll gladly talk it over, without obligation. Just call your nearest Mt. Vernon sales representative.

DIE CASTING CORP.

STAMFORD, CONNECTICUT

RESEARCH PARTICIPANT

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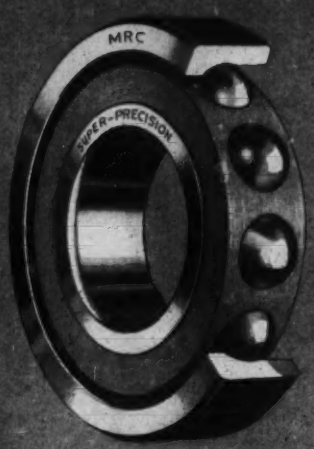
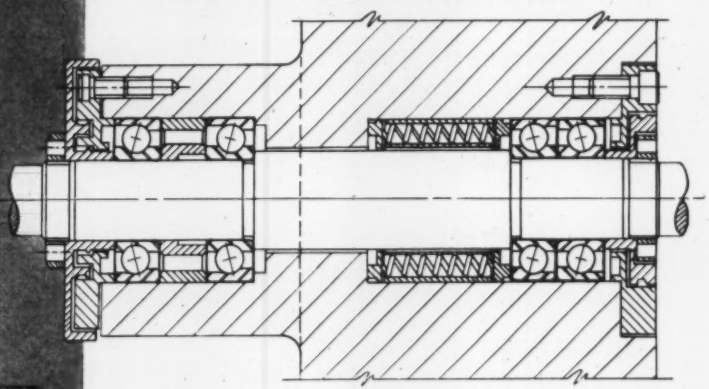
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115

Circle 447 on Page 19

Long life accuracy

IN MACHINE TOOL SPINDLES with M-R-C SUPER-PRECISION BALL BEARINGS





Grinder Spindle

Internal Grinder

Surface Grinder

Hi-Frequency Wheelhead

M-R-C Ball Bearings are used today in many leading machine tool spindles operating successfully at 100,000 RPM and over.

The illustration above is an example of a successful application of M-R-C SUPER-PRECISION bearings. This grinder spindle requires the highest degree of accuracy and long life obtainable only with M-R-C SUPER-PRECISION.

Still higher standards have been made possible by the facilities of our new SUPER-PRECISION plant devoted exclusively to this type bearing.

There is a M-R-C Ball Bearing for every machine tool application requiring accuracy and long life.

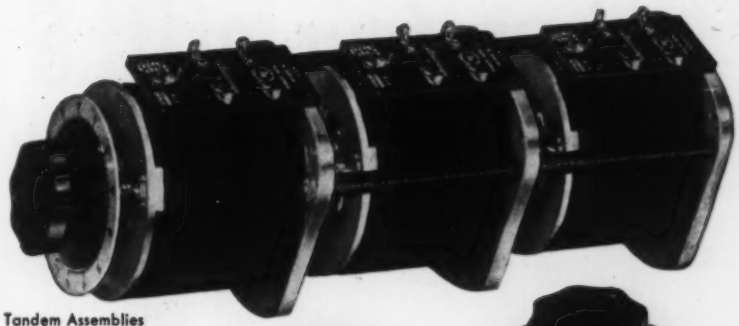
Consult OUR Engineering Department on YOUR bearing problems

MRC
BALL AND ROLLER *bearings*

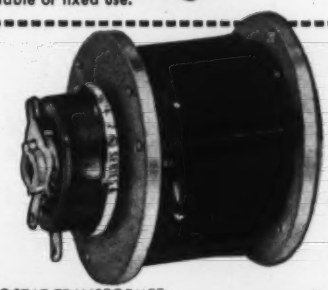
MARLIN-ROCKWELL CORPORATION

Executive Offices: **Jamestown, N.Y.**

Enclosures for portable or fixed use.

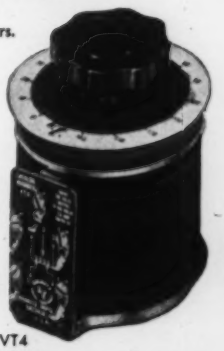


Tandem Assemblies in all three sizes of Ohmite Variable Transformers.

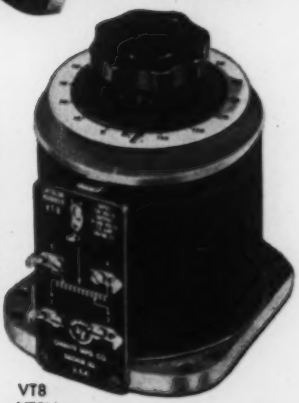


RHEOSTAT-TRANSFORMER TANDEM ASSEMBLIES. EXCLUSIVE WITH OHMITE

VT2
VT2N



VT4
VT4N



VT8
VT8N

OHMITE® "V.t." Variable Transformers Give a "Bonus" in Current Capacity

EXPANDED LINE—Ohmite now offers industry six basic models with current ratings sufficient to meet a large percentage of industrial applications. The new line includes enclosed units and tandem assemblies. Two models, VT2 and VT4, offer capacity greater than competitive units of comparable size and price. *An additional and sizeable "bonus" in current* is given in all sizes when the overvoltage feature is not required ("N" suffix, see below).

ADVANCED FEATURES—Positive current transfer achieved with direct brush to slip-ring, pig-tailed connection; table or panel mounting—on VT4 and VT8 sizes, adjustable shaft moves to brush or base side; interchangeable with other popular types both electrically and "mounting-wise"; durable rhodium plating on brush track for longer life.

SPECIALS ENGINEERED FOR YOUR NEEDS—Transformers can be modified to meet different requirements such as special shafts for nonstandard panel thicknesses, auxiliary switches, taps on transformer winding for fixed intermediate voltages, and motor drives for remote control or servo-operation. The only manufacturer in the industry concurrently producing power rheostats, tap switches, and variable transformers, OHMITE can also offer in-tandem combinations of these items.

BASIC MODELS (with overvoltage) All inputs 120 v ac*

MODEL VT2	MODEL VT4	MODEL VT8
Volts output: 0-120/132	Volts output: 0-120/140	Volts output: 0-120/140
Amps output: 1.5	Amps output: 3.5	Amps output: 7.5

BASIC MODELS (without overvoltage) All inputs 120 v ac*

MODEL VT2N	MODEL VT4N	MODEL VT8N
Volts output: 0-120	Volts output: 0-120	Volts output: 0-120
Amps output: 1.8	Amps output: 4.75	Amps output: 10.0

**Units available for 240-volt input also*

Write for Bulletin 151

Available from Ohmite Distributors or direct from factory

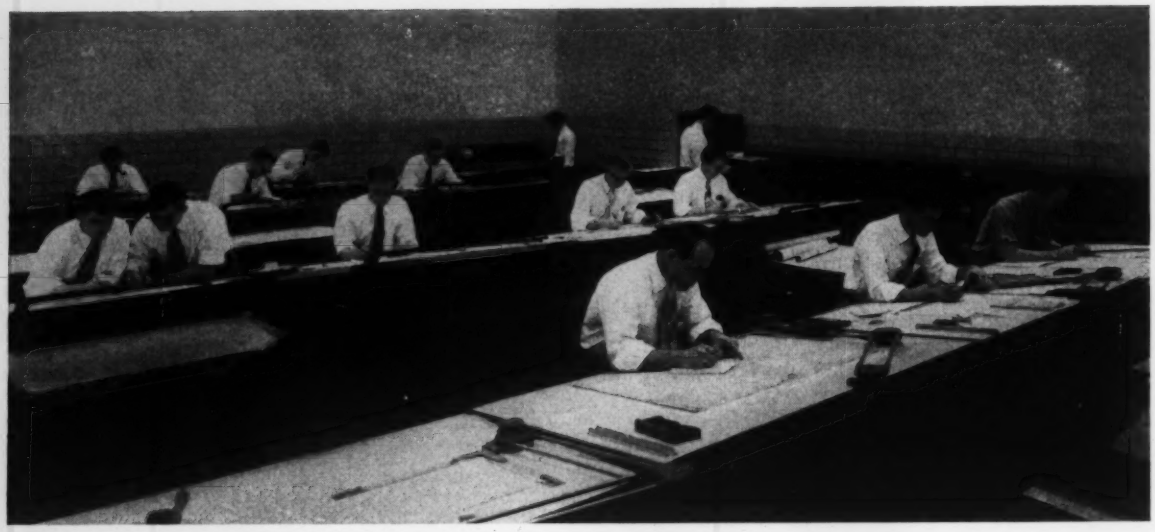
OHMITE® QUALITY Components

OHMITE MANUFACTURING COMPANY | **3618 Howard Street Skokie, Illinois**

RHEOSTATS RESISTORS RELAYS TAP SWITCHES R.F. CHOKES
VARIABLE TRANSFORMERS TANTALUM CAPACITORS DIODES

Circle 449 on Page 19

. . . how four of the engineering help you . . . the



1 The advanced product and process engineers at each of our plants are available to assist you with the casting design considerations. It is Central Foundry's practice to suggest design changes that ordinarily do not affect the part functionally, but often reduce casting weight, thus reducing casting costs. Your blueprints are returned to you with parting line, coring and gate locations as well as suggested changes in casting design clearly marked.

Our engineering staff is specialized to give you expert assistance in each of the metals Central Foundry produces. When you are considering castings of ArmaSteel, malleable iron or grey iron to be cast in either green sand molds or by the more exacting shell mold process, contact the sales department of Central Foundry Division.

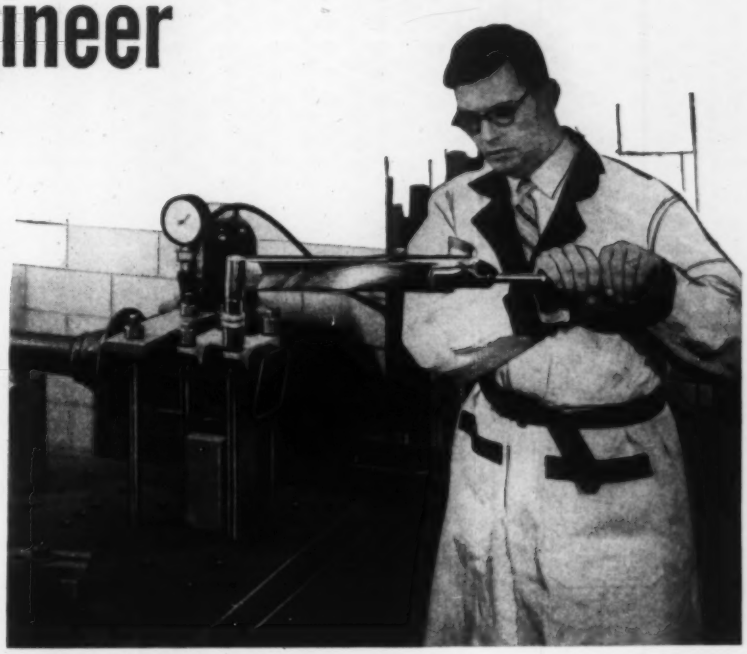
2 Cobalt 60 radiography, a fast, positive method of detecting sub-surface defects, has replaced time consuming breaking, cutting and etching of castings, formerly used by the foundry industry to check new parts for soundness. This technique does not demand destruction of the part and gives positive location of any defects. With radiographs as a guide, our engineers can make necessary changes in gating, feeding and general design that assure quality castings at reduced cost, and do it in hours compared to days required for breaking or cutting.

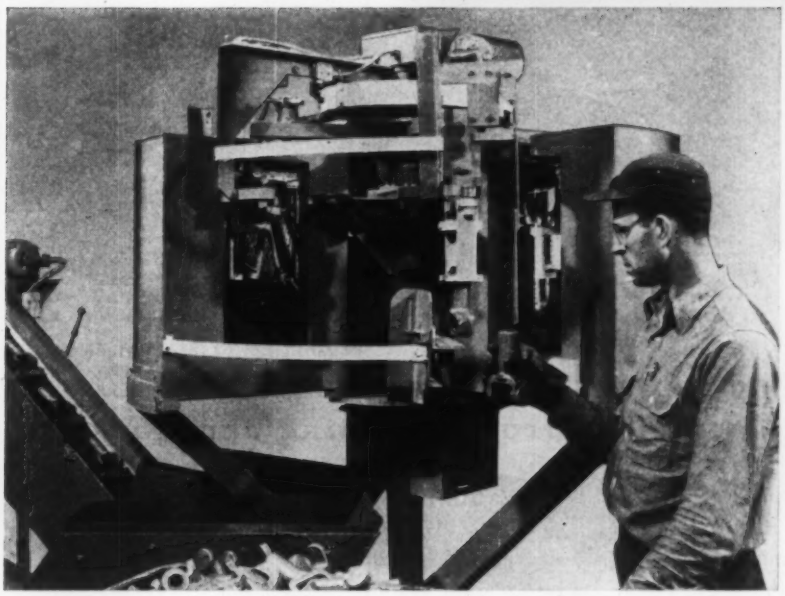
CENTRAL FOUNDRY DIVISION · GENERAL MOTORS CORPORATION

CENTRAL FOUNDRY DIVISION

services at Central Foundry design engineer

3 Stress Analysis is also used at Central Foundry in the design or redesign of castings to reduce weight and improve mechanical strength. By an accurate study of stress, both statically and dynamically, Central Foundry engineers are able to suggest design changes, to put metal where it is needed, remove excess material, to recommend the best material for your part and thus assure the highest quality castings at the lowest possible cost.





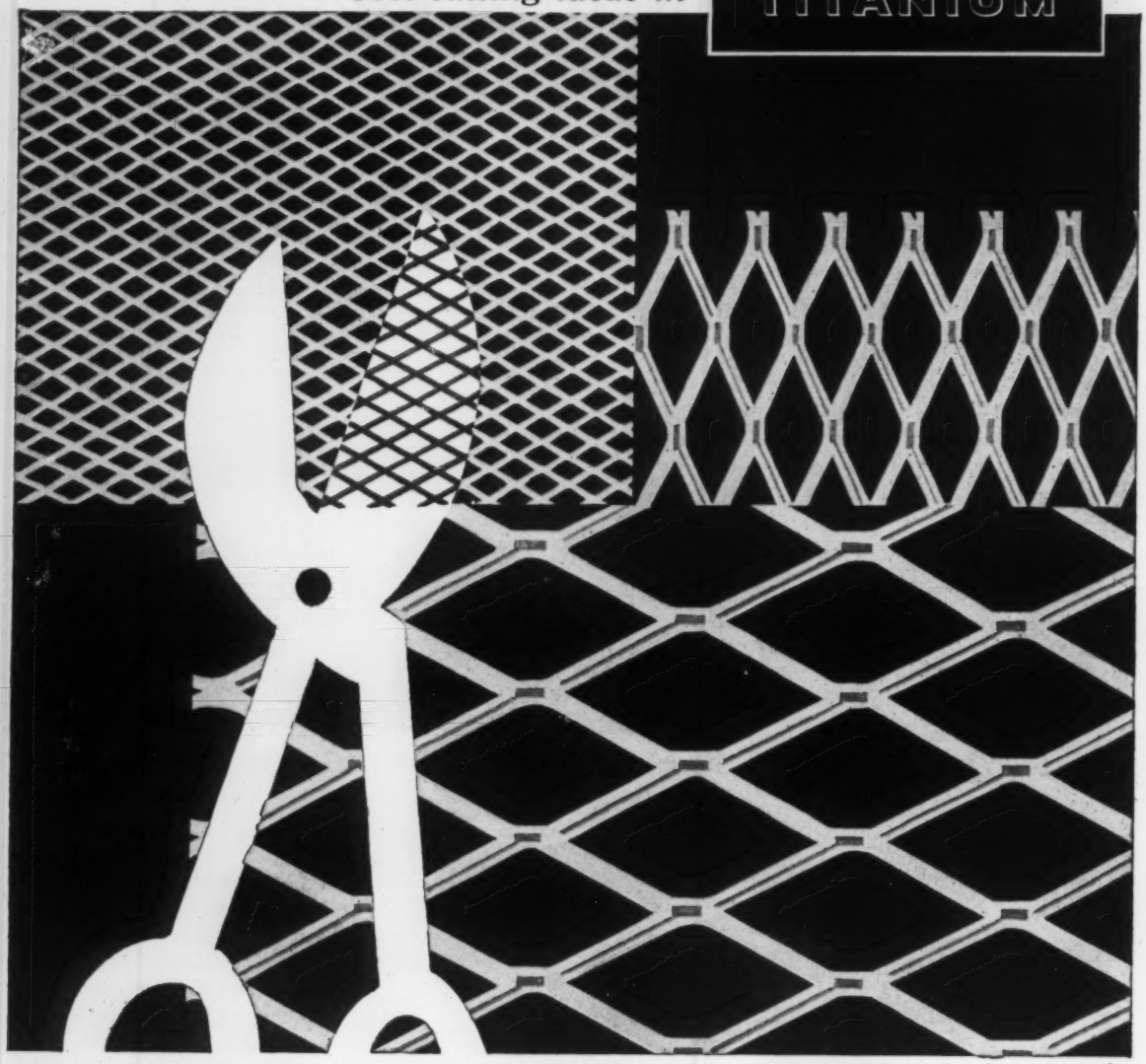
4 Sonic testing is an electronic listening device developed by Central Foundry that automatically distinguishes between the vibrations of good and faulty castings and sorts them accordingly. The sonic testing machine, much faster and more accurate than visual inspection, eliminates human error and is ideally suited to high production of castings designed for critical applications.

Central Foundry, with plants in Saginaw, Michigan, Defiance, Ohio, and Danville, Illinois, has the vast facilities and engineering services necessary to deliver, on schedule, quality castings in production quantities. Our sales engineers, product development engineers, foundry engineers and modern engineering services are all available to help you get quality castings . . . at low cost . . . in less time.

MEMBER MALLEABLE CASTINGS COUNCIL

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

Cost cutting ideas in **TITANIUM**



Visit our Booth No. 1151 at Western Metal Exposition, March 16-20, Pan-Pacific Auditorium, Los Angeles.

EXPANDED TITANIUM SHEET

"opens up" new savings in corrosive plating applications

Now, cost-saving applications for titanium take another important step forward. Expanded titanium sheet, recently introduced by Mallory-Sharon, offers interesting possibilities for use in the plating and chemical processing industries.

Dip baskets

Filters

Its high corrosion resistance makes it ideal for use in acid plating, acid dipping baskets, and in protection shields for immersion heating electrodes. The new material is available in gauges from .015" to .125", from ⅛" to 1½" diamonds, and in standard 48" x 96" sheets.

Protective shields

Expanded titanium sheet is now available in production quantities. Prices vary with gauge and strand widths. For further information, write for Technical Data Sheet.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

Circle 451 on Page 19

News! The best features of
modern bearing design combined and refined in

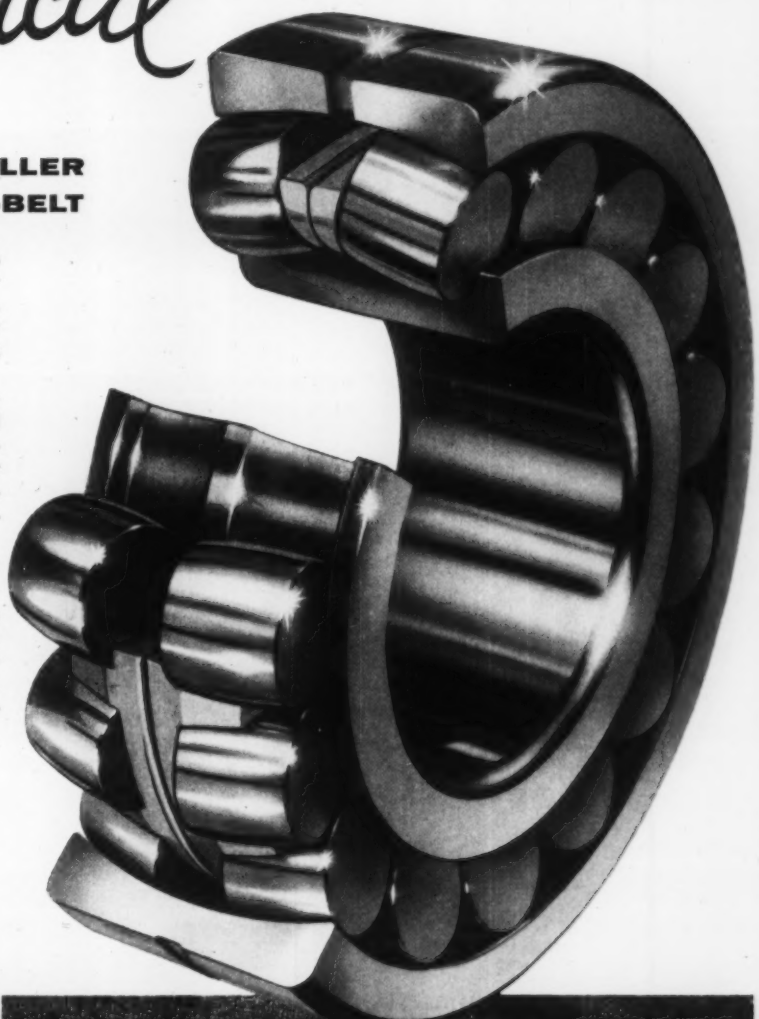
Spherical

SELF-ALIGNING ROLLER BEARINGS BY LINK-BELT

BIG, mirror-smooth convex rollers *plus* heavy, broad-shouldered inner race *plus* centrifugally-cast bronze, precision-machined retainers! Only from Link-Belt do you get ALL that is best in modern bearing design.

Individually, these elements represent major improvements on accepted design concepts. Collectively, they constitute the most efficient spherical roller bearings available . . . promise unequalled economies, whatever the application.

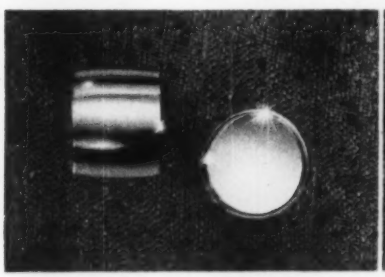
Your Link-Belt office will gladly explain the many performance advantages evolved with this new design. It can furnish full data on industry's most complete line of ball and roller bearings . . . pillow blocks and flanged, flanged-cartridge, cartridge, and take-up blocks.



LINK-BELT

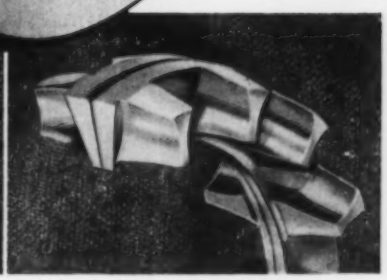
MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. Plants, Sales Offices and Distributors in All Principal Cities. 14,819-A



BIG, HIGHEST-CAPACITY ROLLERS. Each bearing has a maximum number of rollers—as large as possible, yet all components are in optimum balance.

HIGH, HEAVY INNER RACE FLANGES present convenient hold for assembly and removal of bearing without cutting away shaft, avoid any need to skimp on shaft shoulders.



PRECISION-MACHINED, CENTRIFUGALLY-CAST BRONZE RETAINERS have many times more support and ability to withstand high stress. They are not stampings. Design assures maximum bearing efficiency.

Circle 452 on Page 19

SAVE DRAFTING TIME WITH

CLEARPRINT® "FADE-OUT PRE-PRINT" FORMS

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PRE-PRINTED
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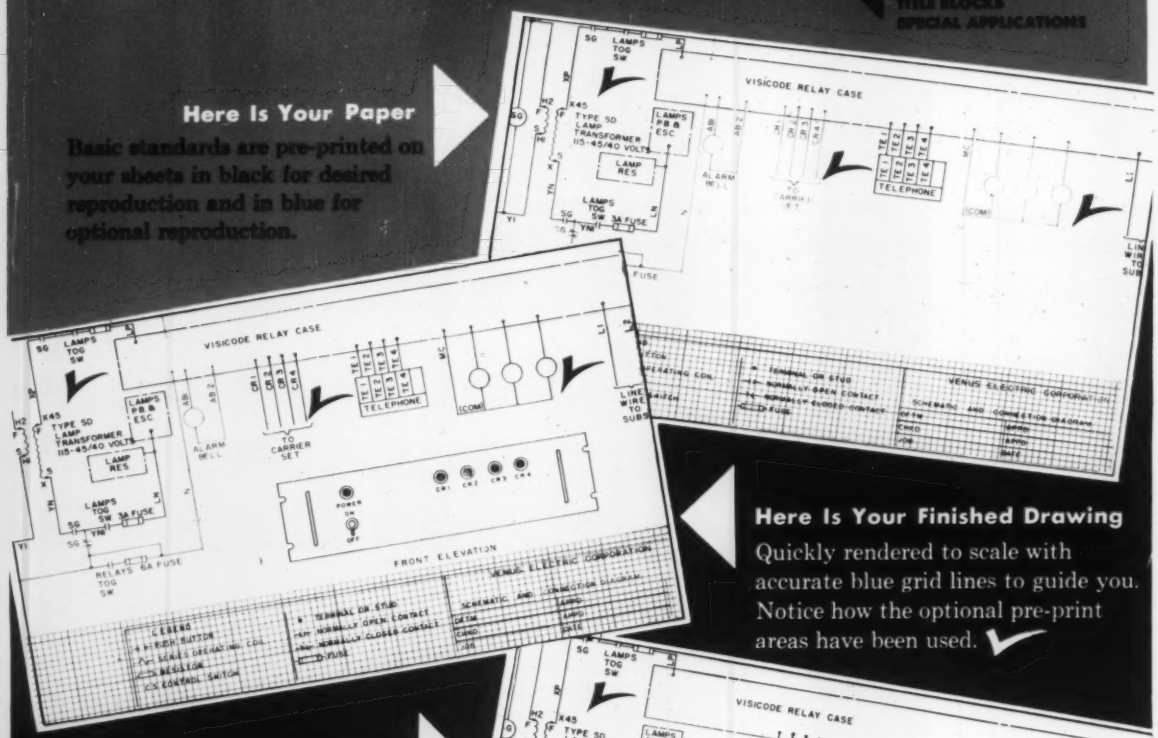
Basic standards are pre-printed on your sheets in black for desired reproduction and in blue for optional reproduction.



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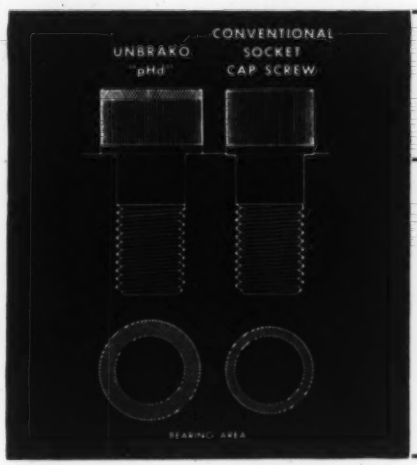
SPS RELIABILITY / *A dynamic standard of predictable performance*

Larger head diameter of UNBRAKO pHd* socket cap screws increases load-carrying capacity up to 233%



*Proper Head Design—a factor in higher product reliability.

COMPARISON OF UNBRAKO pHd AND CONVENTIONAL DESIGN

Each size can now be utilized with equal reliability. The bearing stress is consistent from size to size in the new UNBRAKO pHd socket cap screws.

SCREW SIZE	HEAD DIAMETER (in.)		BEARING AREA (sq. in.)		LOAD TO INDENT IN CAST IRON (lb.)		% INCREASE USABLE STRENGTH	TIGHTENING TORQUE (lb.-in.)‡	
	Old	pHd	Old	pHd	Old	pHd		Old	pHd
¼	.375	.375	.041	.041	3,280	3,280	—	165	180
5/16	.438	.468	.047	.072	3,760	5,760	54	325	360
3/8	.562	.562	.102	.102	8,150	8,150	—	600	660
7/16	.625	.656	.116	.148	9,270	11,800	27	1,000	1,040
½	.750	.750	.188	.188	15,000	15,000	—	1,450	1,590
9/16	.875	.937	.203	.305	16,200	24,400	51	2,900	3,190
¾	1.000	1.125	.223	.432	17,800	34,600	94	5,050	5,600
7/8	1.125	1.312	.254	.594	20,300	47,500	134	8,000	8,900
1	1.312	1.500	.364	.785	29,100	62,800	116	10,550	13,600

‡Normal recommended seating torques for unplated screws, fine threads.

For you, pHd means sounder fastening, with resultant increases in product reliability at no increase in price. With pHd UNBRAKO socket cap screws you get stronger, more reliable joints; space and weight saving through use of smaller or fewer fasteners; greater fatigue resistance through application of consistently higher preloads; fewer fasteners working loose under vibration or shock; and elimination of washers under cap screw heads in many applications.

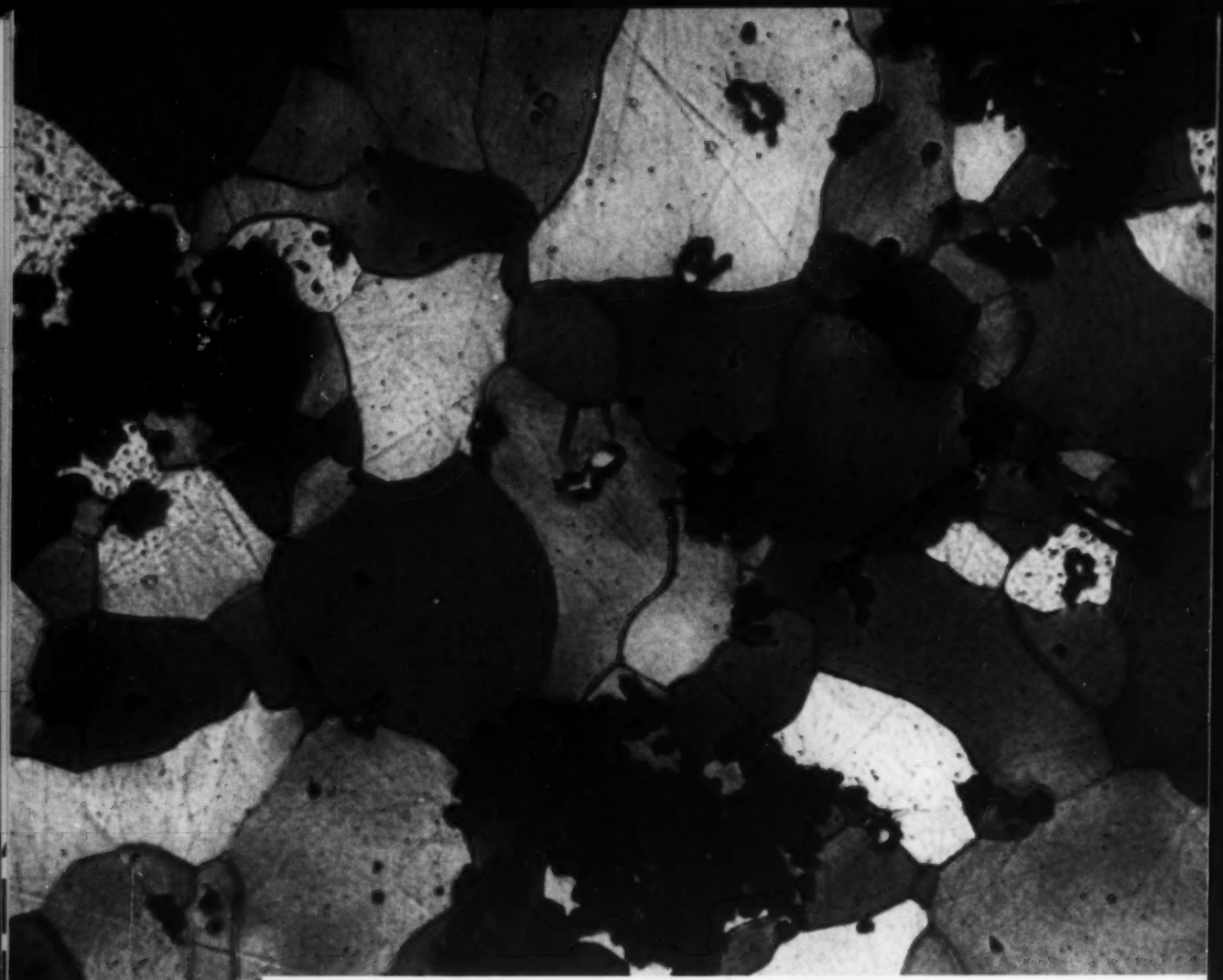
The principal reasons for the superior performance of broad-bearing pHd UNBRAKO socket cap screws are up to 233% more load-carrying capacity than with a conventional cap screw and the ability to be tightened tighter. Because of increased bearing area, the vital preload that keeps screws tight and prevents fatigue failures is distributed over more of the bolted material. Indentation under high working load is eliminated. And pHd UNBRAKO screws have been designed for high tightening. In many cases the socket has been enlarged for better key engagement. Combined with this feature is the fact that all the tightening force is used to preload the screw, in contrast with the conventional cap screw—where indentation saps some or all of the tightening force.

See your authorized SPS industrial distributor for complete details. Or write SPS—manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

Circle 454 on Page 19



Color micrograph of heat tinted section of ferritic Malleable iron showing random dispersion of temper carbon nodules in ferrite. 625X magnification.

Usability is Malleable

In the growing world of metals, certain requirements remain basic: strength . . . versatility . . . economy. Malleable iron castings uniquely answer all three. Malleable castings provide more strength per dollar than any other metal . . . are the most machinable of all ferrous metals of similar hardness.

From the great range of Malleable irons now produced in modern Malleable foundries, you can select exactly the right metal to fill your most demanding needs for endurance, resistance to impact and wear, ductility and constant uniformity. No other metal offers you so much at so low a cost.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER

MALLEABLE

CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, 1800 Union Commerce Building, Cleveland 14, Ohio, for information.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

How to Select the Best Metal to Perform a Given Set of Functions

Any equipment part can be described, at least approximately, in terms of the functions it must perform. That is, it must provide a certain strength plus resistance to wear, fatigue, impact or corrosion. The finished part must provide the best combination of all necessary factors at the lowest possible cost — a cost that must include machining, finishing and assembly where applicable.

Unique Production Method Combines Desirable Characteristics

The amount and form of carbon in ferrous metals is of prime importance. The carbon content of Malleable iron (2.00 to 2.60%) provides good fluidity at the pouring stage. Yet neither flake graphite nor combined carbon is present in finished standard Malleable iron.

As the photomicrograph of standard Malleable iron shows, the carbon has been transformed into temper carbon nodules in a matrix of ferrite during the heat-treatment given *all* Malleable iron castings. The result is a metal with a unique combination of high strength, toughness and machinability.

Pearlitic Malleable irons differ from standard, or ferritic, Malleable only in that a controlled amount of the carbon is combined with the iron to form a pearlitic matrix around the temper carbon nodules. This increases strength, hardness, wear resistance and modulus of elasticity, while retaining good ductility and machinability.

TENSILE PROPERTIES — A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons				
Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Elongation % in 2 in.	Ratio of Tensile to Yield %
Standard				
35018	53,000	35,000	18	66
32510	50,000	32,500	10	65
Pearlitic				
45010	65,000	45,000	10	69
45007	68,000	45,000	7	66
48004	70,000	48,000	4	69
50007	75,000	50,000	7	67
53004	80,000	53,000	4	66
60003	80,000	60,000	3	75
80002	100,000	80,000	2	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

TYPICAL BRINELL HARDNESS NO. RANGES

	Pearlitic Malleable Irons						
Designation	45010	45007	48004	50007	53004	60003	80002
B. H. N.	163-207	163-217	163-228	179-228	197-241	197-255	241-269

New Savings Result

From the wide range of properties obtainable, a Malleable iron may be selected that will most completely meet ideal design and functional requirements. Because of the great latitude of producible sizes, from a fraction of an ounce to hundreds of pounds, Malleable can be used for a wealth of applications.

Malleable iron's economy is derived in two ways. First, the casting process is generally accepted as the most economical method of producing a finished part. Secondly, being the most machinable of all ferrous metals of similar hardness, cast or otherwise, Malleable iron castings provide exceptional economies in time, tool and power consumption.

Today's Malleable iron castings offer tremendous strength, uniformity, versatility and economy. The producers of Malleable castings are anxious to assist you in getting maximum "usability." Why not let their modern design, testing and production facilities work for you?

Send for Special Data Unit

Your copy of Data Unit No. 101 containing additional information on the benefits you can derive from Malleable iron castings is available from any member of the Malleable Castings Council. If you wish, you may direct your request to **Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.**

Circle 455 on Page 19

the Bigger the job, the More it needs

DIAMOND
ROLLER CHAIN

● This giant 425-thousand-pound boring, drilling and milling machine, built by The G. A. Gray Company, uses 44 feet of double strand DIAMOND Roller Chain.

For every roller chain application *traditional Diamond quality* assures long life of dependable, trouble-free service.

Always specify DIAMOND wherever roller chain is used. Your nearby DIAMOND Distributor has all types and sizes of Roller Chain in stock, ready for instant delivery. For the name of your nearest DIAMOND Distributor consult the Yellow Pages of your telephone directory under the heading CHAINS or CHAINS-ROLLER. Call him Now!

DIAMOND ROLLER CHAINS

DIAMOND CHAIN COMPANY, INC.
A Subsidiary of American Steel Foundries
Dept. 435, 402 Kentucky Avenue, Indianapolis 7, Indiana
Offices and Distributors in All Principal Cities

The head of this machine weighs 27,500 lbs. and operates with a precision of ¼ thousandths of an inch. Two 22-foot DIAMOND Roller Chains, operating over 15-tooth sprockets, insure smooth, dependable operation in this counterweight application.

Circle 456 on Page 19

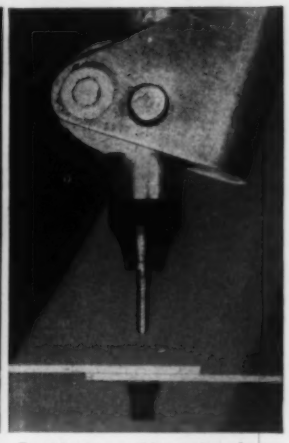
B.F.Goodrich

Rivnuts® fasten thin metal... provide 6 threads in 6 seconds

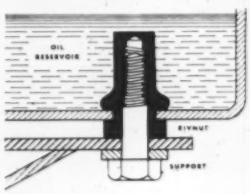
1 Rivnut is threaded onto pull-up stud of heading tool.

2 Rivnut is inserted—head held firmly against work.

3 Tool lever operates pull-up stud, forms bulge in Rivnut.

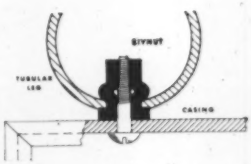


4 After upset, Rivnut threads are ready for screw attachments.



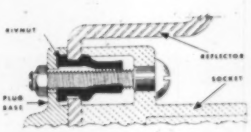
REPLACES BRAZED NUT PLATE

Rivnuts with closed ends are installed in one-tenth the time it took to braze nut plates on oil reservoir tanks. Leaking, warping and thread cleaning are eliminated, and spacer head assures proper positioning of tank on support bracket.



ELIMINATES NUTS AND BOLTS

One worker installs a Rivnut in the tubular leg of a portable barbecue in seconds—provides a firm, accurate nut plate for screw attachment. There are no boltheads to detract from the unit's clean lines. Time is saved, too, in faster knockdown for shipping.



DOES 2 FASTENING JOBS

Rivnuts provide 6-thread nut plate for attachment from either end—or both. In spot-light assembly, Rivnut replaces awkward welded stud for attaching socket. Plug base is attached on other side. Result: fewer operations, lower assembly cost.

B. F. Goodrich Rivnuts—the easy way to cut assembly time . . . costs

Rivnuts, the only one-piece blind fasteners with threads, can be installed by one person from one side of the work—in seconds. Easy installation saves up to 50% of assembly time, reduces production costs. Rivnuts can also improve the appearance of your products and make them easier to use and service.

Rivnuts are made in a variety of sizes and head styles to solve almost any fastening problem. They make tight, dependable seals that resist vibration, stay put so you can assemble and disassemble the product as often as you like without stripping the threads. Welding, tapping and thread cleaning are eliminated. And you can install Rivnuts after enameling without fear of chipping.

B.F.Goodrich Rivnuts have speeded up thousands of fastening jobs. They can do the same for you.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Department MD-39, Akron, Ohio.

B.F.Goodrich aviation products

New! FREE CUSHIONS*

MEAD
DURA-LIFE
CYLINDERS

Compare these prices!

1½" Bore — $29.95	3¼" Bore — $46.40
2½" Bore — $37.80	4" Bore — $53.35

Prices slightly higher West of Rockies.

Write for complete Mead Air Power Catalog

MEAD SPECIALTIES COMPANY • 4114 N. Knox, Dept. MD-39-Chicago 41

Circle 458 on Page 19

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **A plastic for potentially hazardous locations**
- **Material for a non-warping switch**
- **More design freedom in metal castings**

Canopy retards fire

Good product ideas seem to work almost anywhere.

Take, for example, this plastic gas-station canopy. So far as we can tell, the idea of cool, light-diffusing canopies over the gas pumps started in the South, where it would seem to be a natural.

However, the canopy you see here is in Canada. It does most of its work in winter, when it may have to hold up the weight of five feet of snow and ice.

The marketing strategy is sound. A motorist doesn't mind so much getting out of his car in bad weather when he's protected overhead; and the attendant, too, is likelier to provide that extra bit of service.

There's something else that's different about this canopy. It doesn't support combustion, because it's made with Hetron® self-extinguishing polyester resin. A fire starting at a pump won't spread along the canopy to other pumps or to the station building.

If it weren't for self-snuffing Hetron, there'd be few places where a good idea like this could operate. Fire retardance is chemically locked into the resin, not added later at the expense of strength. The resulting combination of structural properties gives you something unique on which to base *your* new-product ideas.

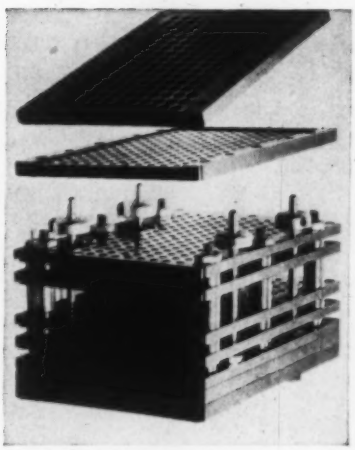
If you'd like to know more about Hetron resins, let us send you the complete technical data file, together with names of leading fabricators in this country and Canada who can make U/L-listed panels and custom-molded shapes for you.

Less dough for this "bread"

Needed: a dimensionally stable material for the "bread" in this sandwich-like multiple switch assembly (above right).

Why dimensionally stable? Because each of the seven "slices" in the sandwich has 187 holes that must line up with matching holes in the other plates.

What low-cost insulating material would hold alignment without risk of moisture absorption and warping? Could



holes be *molded*, rather than drilled, to the required accuracy? Would this save money?

The material recommended by the custom molder was a fast-curing Durez compound with good moldability and excellent dimensional stability. This material does everything the designers want it to do. Its exceptionally good mold release facilitates the low-cost molding of holes. In addition, numbers and letters which were formerly silk-screened on the plates are now molded-in for extra savings.

Result: a smooth-functioning, non-warping switch, produced with the utmost economy. It's just one more proof of the wide, wide spectrum of design requirements you can meet at low cost with Durez phenolics (and often *only* with phenolics). Want more information on these versatile molding compounds? Just check the coupon for a bulletin on Durez materials.

Castings – can do

Don't back off from a complex metal shape just because "it can't be done."

Instead, talk to your foundryman. He may have a surprise up his sleeve—*shell molding*. It saved the day for the aluminum-alloy gearbox cover, below.

Designers wanted as many heat-dissipating fins as possible; they compromised on 40. Even so, fins tore when the piece was poured in sand. Three men could produce only 20 good castings a day.

A switch to shell molding has made the casting economically feasible. Three men now turn out 70 per day. Dimensions are much more consistent from one casting to the next. As a bonus, engineers found they could squeeze two more fins into the design to get higher efficiency than they first believed possible.

What about cost? Shell-molded castings sometimes cost more *per pound* than regular castings. But they often save you far more than the difference—by reducing machining and finishing time and by speeding assembly.

Like to know how these better castings are made with the help of Durez foundry resins? We'll gladly send you the new 36-page "Durez Guide to Shell Molding" if you check the coupon below.

For more information on the Durez materials mentioned above, check here:

- ☐ Hetron fire-retardant polyester resins (50A)
- ☐ General bulletin on Durez materials (Bulletin 400)
- ☐ "Durez Guide to Shell Molding" (36-page bulletin)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER CHEMICAL CORPORATION
503 Walck Road, North Tonawanda, N. Y.

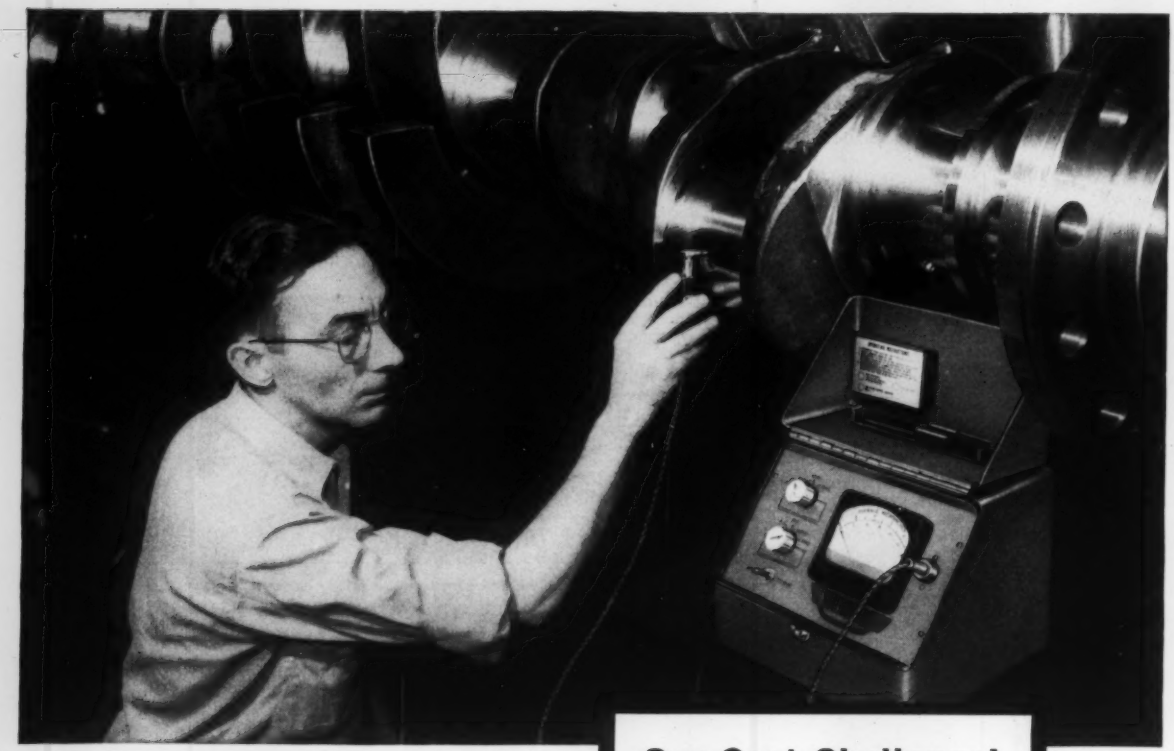
Circle 459 on Page 19

Specify your finish...

enforce it with the Brush Surfindicator!

With the Brush Surfindicator you can hold finishes *exactly* to specifications. No costly rejects. You get a specification finish at minimum cost! The Brush Surfindicator with its full range of accessories precisely measures any finish regardless of whether it's rough, smooth, in a hole, on a concave or convex surface—even on a razor edge.

Write for booklet "Control the Finish and You Control the Costs." Factory-trained distributors in all major cities.



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DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

Our Cost Challenge!

Just invite us to bring the Surfindicator into your plant—put it to work on a machine—and we will prove that we can reduce your rejects. We're ready now!

interchangeable with all standard JIC cylinders

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

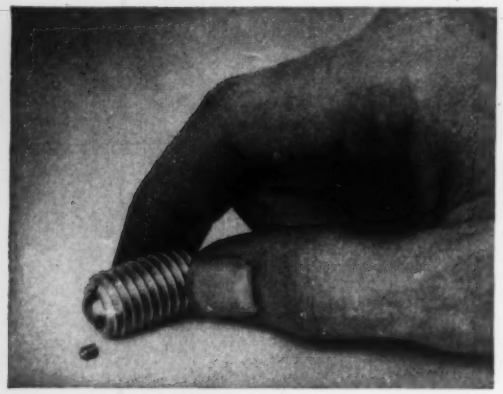
T-J TOMKINS-JOHNSON

Circle 461 on Page 19

Practical Design Tips

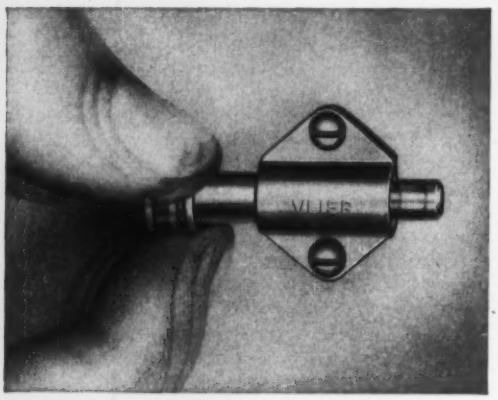
No. 4 of a series

Hundreds of companies are now saving by using off-the-shelf Vlier products like the ones shown below. These simple, low cost, precision parts save designers time and, in many cases, simplify product design and manufacture. Why not investigate their possibilities today.



BALL PLUNGERS WORK BETTER than spring plungers when side loads are involved. Balls won't bind from side thrusts, retract easily. Available in new, "Mini-ball" sizes, down to #4-48x3/16"; standard sizes from #10-32x1/2" to 5/8-11x1". Various end pressures.

TORQUE-LIMITING WRENCH for assembling small parts, adjusting set screws, etc., is easily made from a Vlier Torque Handle and a length of hexagon stock. Prevents over-tightening, and subsequent damage to parts. End pressure is adjustable from 15 to 200 lbs.

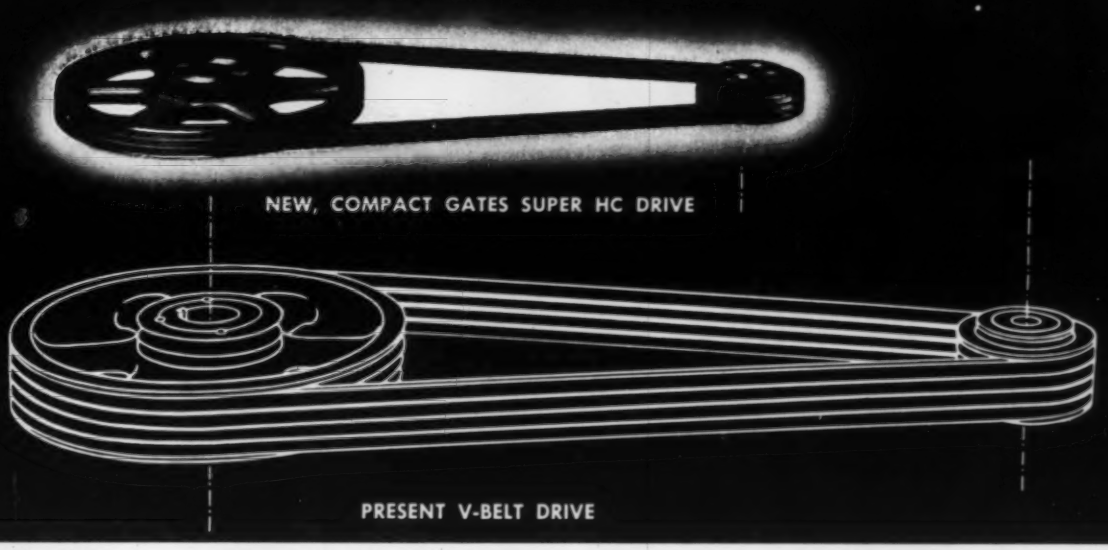


NEED A SMALL, LIGHTWEIGHT, SPRING-LOADED LATCH? One enterprising designer modified a standard Vlier S-88 Spring Stop that did the job perfectly. Entire latch weighs less than 1/3 oz. Body is die-cast aluminum; plunger is heat-treated alloy steel. Various plunger pressures. Available on quantity orders only.

FREE IDEA BOOKLET. Illustrations in this 16-page booklet show how others have profited from the use of Vlier products. Illustrates both the usual and unusual applications. May suggest ways *you* can save. Write for your copy today.

VLIER
Engineering Corporation
A subsidiary of Barry Controls, Inc.
8900 Santa Monica Blvd. • Los Angeles 46, California

New high capacity V-belt revolutionizes drive design



Makes drives far more compact... cuts cost as much as 20%

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Learn more about the cost-saving Super HC Drive

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Present Drive	7.4"	20.0"	42.9"	4
Super HC Drive	5.3"	14.0"	30.0"	3

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Gates Super HC V-Belt Drives

Circle 463 on Page 19

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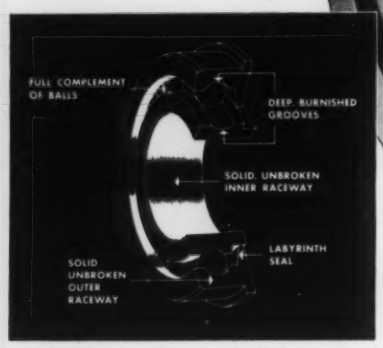

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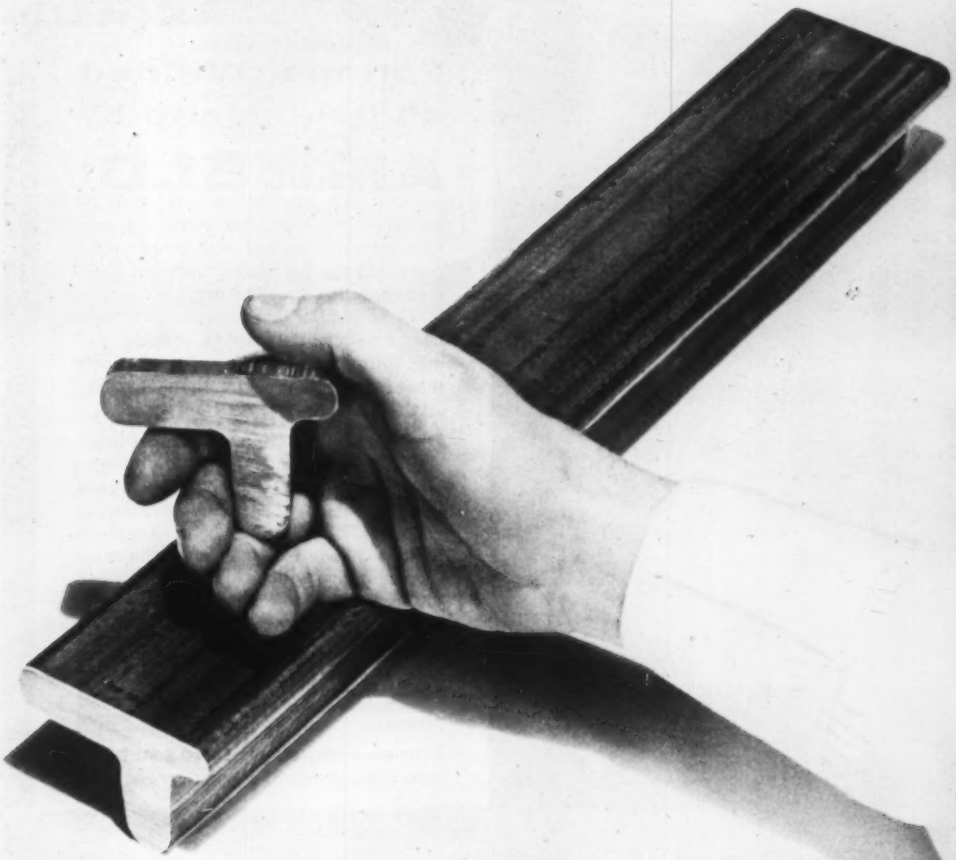

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Industrial Timer also manufactures this Punched Tape Programmer which controls 85 individual load circuits through an unlimited number of steps. No coding or elaborate memory systems are required, making possible direct control from Programmer to process.

Between these two extremes we list 1688 different timers, of which 39 are standard types and 1649 are "specials" developed to solve difficult control problems.

Most timing problems have their own unique characteristics. However, it very often happens that a control problem is quickly solved by one of these 1649 already developed special timers. If not, we have the staff, the experience (20 years) and what's more important, the desire to design and deliver the timer that fills your needs 100%. Send us your specifications.

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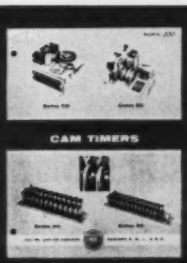
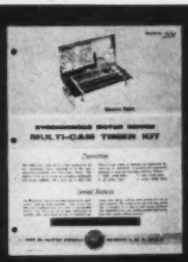


No. 200 Motor Driven Cam Timers



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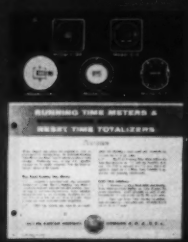

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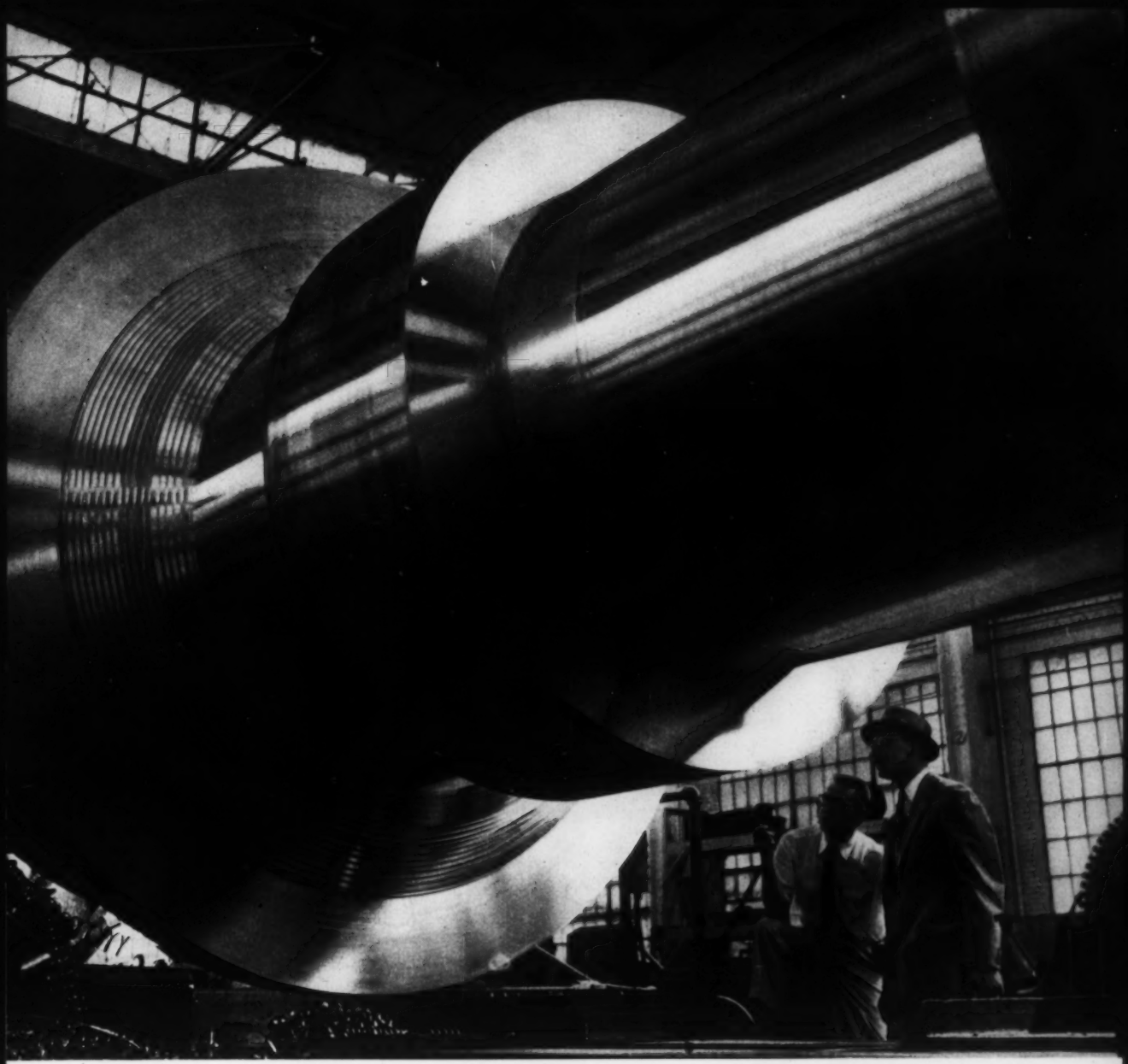

Huge shaft to help make power hum

This forged generator shaft is a giant that will do a giant's work. At one of the great Northwestern dams it will take its place in the hydroelectric plant.

The big forging weighs 95 tons, is more than 33 ft long, and has a 15½-in. bore throughout its entire length. Made of carbon-vanadium steel, it was carefully heat-treated to produce the desired mechanical properties.

Huge shafts like this, and other high-tonnage items, are no strangers to the Bethlehem forge and machine shops. Yet Bethlehem forged products are not always king-size. We are equipped to handle all weights and shapes, from the real giants of the family to midget drop forgings.

Call us whenever we can be of service. No matter how complex your designs, Bethlehem technicians will meet all specifications. When Bethlehem does the job, you can be doubly sure of its quality.

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Circle 469 on Page 19

Dr. J. N. BERRETTONI, *Director of Statistical Quality Control, asks...*

What's your fastener AQL?

Here are important keys to obtaining *guaranteed fastener quality* to meet your specific needs.

Careful evaluation of print tolerances is the first step. This means placing each dimension into a critical, major or minor category. For example, a major category may be one where only one dimension in a hundred is allowed to be out-of-tolerance. This 1% then becomes the Accepted Quality Level (AQL). The same type of evaluation is applied to physical and chemical characteristics, plating requirements.

Clear definition of your quality levels can also help reduce your costs. Example: recent quality evaluation of a special fastener showed that, out of a total of twelve dimensions, only two were "majors". Why pay for twelve major dimensions when only two are really essential?

L & S quality level guarantees, evidenced by written certifications, are based on the extensive use of statistical quality control methods. We use MIL-STD-105A, MIL-STD-414, and Dodge and Romig tables to certify incoming raw material and outgoing finished product. For process certification, quality control methods and charts of Dr. W. A. Shewhart are employed at every stage of manufacturing.

Take advantage of this strict L & S Quality Control to cut your receiving and in-process inspection costs.

L & S Fastener Engineering helps you "tighten up" on...

- **PURCHASING COSTS**
- **INSPECTION AND HANDLING COSTS**
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Circle 470 on Page 19

MACHINE DESIGN
March 5, 1959

Head Shrinker at Work

NO TWO men are alike, and both are darn glad of it—we heard someone say recently. And this observation seems to hold for vocations, too.

Doctor, lawyer, salesman, engineer—each of these labels flashes a typical but different specimen in the mind's eye of the layman.

So, other people think engineers are a breed apart. And we as engineers think we are, too. Some of us are even glad that we are not like salesmen or lawyers or executives or what have you. We are not happy back slappers nor glib word merchants nor hasty-decision opportunists.

We take other people as they are. We are factual and unemotional in our dealings with others. We are articulate with drawings and numbers rather than with words.

At Purdue last fall a psychologist examined these kinds of attributes in a talk before several hundred engineers from industry. He told how such matters bear upon the job future of an engineer.

Did engineers agree with him? Of course not. Or if we did, we didn't like what we heard.

He took these things we proudly display and turned them against us. Our "virtues" began to look like hindrances. We were left encumbered and ill-equipped for the struggle to advance personally.

This isn't the whole story. Dr. Wallen's collective appraisal of engineers begins overleaf. Do *you* agree with him?

Ben Hummel

ASSOCIATE MANAGING EDITOR

What does "getting ahead" mean for engineers?
What are the opportunities?
What does it take?
What does it "cost"?

Here's how a psychologist looks at

ENGINEERS, like most people, are interested in getting ahead. This interest stems from a belief so characteristic of America that it is known as "the American dream." It is the notion that anybody, from any station in life, has the possibility of reaching a front-rank position.

The "dream" is best exemplified by Abraham Lincoln, the man who studied by firelight and eventually became president of the United States. Some people believe the American dream is no longer realistic hope but only futile self-deception. Actually, the dream is not dead. In our own generation, we have an example of a farm lad from the Midwest rising to the presidency.

Now, what do we mean by getting ahead? What constitutes advancement? For us it seems to be composed of at least three things. One is increasing income. We expect added experience and knowledge to be rewarded by higher salaries. But that's not all.

A second component of getting ahead is an increase in status. While status is a difficult matter to pin down precisely, most of us know when our status has improved. It seems to be something that cannot be measured by directly examining a man, but only by examining the amount of deference and recognition that other people give him. It also is measured by a number of indicators or "status badges." Having a private office is a sign of higher status than sharing an office with someone else. And so is having a personal secretary as against using a secretarial pool.

The third characteristic of advancement is increased power: An increase in responsibility and in the right to make decisions affecting large numbers of people and large sums of money. Ordinarily an increase in power is also accompanied by an increase in status and in income. These three things, then, are at the core of what we mean by "getting ahead."

Of course, there are other ways in which people want to improve. Many people are much more interested in self-improvement or self-actualization. They want to become more creative, to develop their talents, to arrive at a more meaningful relationship between themselves and the world around them.

There are other people who are dedicated to the growing of things. The growing of plants, of people, or of their families means almost everything to them, and they sacrifice to make this growth possible. For others, a prime goal is to be the center of attention, to be admired and approved. Income and status are secondary goals for them.

The point is that people have deep-seated needs that determine the course they shall follow in finding a satisfying life. Not everyone really wants to "get ahead" in the typical American way. But most

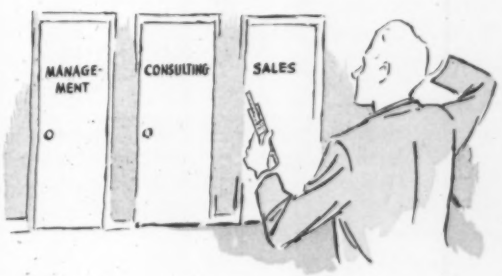
By RICHARD W. WALLEN
Director
Division of Managerial Training
Personnel Research and Development Corp.
Cleveland, Ohio

The Future of an Engineer

of us hardly recognize our own basic desires. The belief that we ought to get ahead is so strong that it buries our other, more personal urges. The result is that when you ask men about their future they almost invariably define it in terms of "getting ahead."

PART of my work is to make psychological assessments of men for management positions. One of the questions I ask is, "Where do you want to be ten years from now?" Now, imagine a man who gives this answer: "I don't know what kind of a position I want nor exactly what level of income I would like to have. But I do know that I want to be more than I am now. I want to be more tolerant and understanding. I want to know myself better. I want to understand other people better, and I want to be more at peace with myself than I am now."

That kind of an answer would surprise both you and me. It is not the right kind of answer. It is deviant. Most of us believe that the proper answer is: "I want to be earning $25,000 a year and to be an executive vice president." We can understand that kind of answer. But it is not really the true answer for many people. And before you define your future in terms of getting ahead, you ought to think about what you really want out of life, and whether that kind of advancement is genuinely in accord with the deep values you hold. Of course, there are many people for whom "getting ahead" will be genuinely satisfying, and it is mainly to that group that the remainder of this discussion will be directed.



ENGINEERS typically think that they do not have much opportunity for advancement, and this is probably true. Their common complaint is that there is no place for them to go. In the usual organizational arrangement today, an engineer can improve his income and still remain an engineer. But rarely can he improve his status and power, without leaving engineering behind.

There are a few exceptions to this, of course. A few companies have created high-ranking positions for scientists and engineers, so that they can reach a status equivalent to that of a vice president and still carry on their specialty. By and large, however, if an engineer wants to advance he must follow a path that makes engineering activity sec-

ondary to something else.

Three main kinds of roads to advancement are possible. One of these is management. The engineer can rise to a supervisory position, and then into middle and top management.

A second broad area of advancement is selling. That activity can provide a substantial increase in income and, sometimes, in status.

The last alternative is consulting. The engineer may become a consultant on his own or he may join a consulting firm.

Unfortunately, these occupations, management, sales, and consulting, are not the same as engineering. They require new kinds of skills, new information, new viewpoints. Therefore, an engineer who plans to advance must appreciate the fact that he will be changing his occupation.

Let me dramatize this change for you. Suppose after ten years as a mechanical engineer you decide that you would like to be a professor of literature in a university. The order of magnitude of change required for such an occupational shift is only a little greater than that required for a man to shift from an engineering position to a sales, management, or consulting position.

But what is required to make such a shift successfully? We have some information about the personal and social characteristics of men who move up the management ladder. And we can supplement this information with some good guesses.

ONE obvious fact about these "upward-mobile" men is that they are highly intelligent. They learn quickly, and they remember well. Also, many of them have broadened their formal education beyond their first specialty.

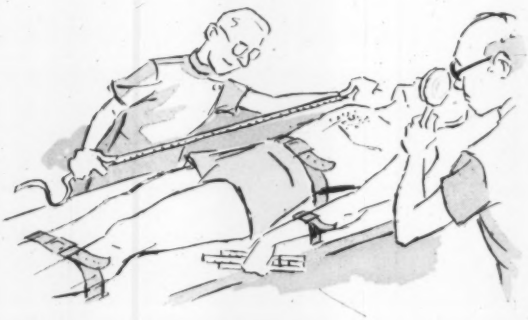
But apparently the most important characteristic of the upward-mobile man is the ability to leave people behind. Basically, no one can come to mean too much to the man who is moving upward. New opportunities require a man to leave one company and go to another. Serving his apprenticeship in one, he moves to another to learn supervision, and to another to learn the essentials of management. Even when his advancement is within a single company, he must leave people behind.

He changes to new luncheon companions, new golf partners, and he spends his social evenings among new hosts and guests. As men advance, they move further from the center of cities, to the right suburb, to the appropriate address. Their choice in automobiles, that great American badge of status, changes from the Plymouth and Ford, through the Buick and De Soto, to the Cadillac and Continental. Even eating habits change. A luncheon of grapefruit and black coffee with a bit of Melba toast on the side is not common among junior management.

Yes, the man who is on the move must be able to leave friends behind him. He is no shallow opportunist, however. It is simply that he is capable of forming emotional attachments that are not too strong. He can appreciate people but avoids becoming deeply and intimately related to them. Or, in psychological jargon, his needs for affiliation are not very intense. And while he can often become quite close to an admired boss, he cannot allow anybody else to mean a great deal to him.

Another important characteristic of the upward-mobile man is that he is fiercely focused on his career. Few people realize the number of hours that management people spend in their work. For them, a sixty-hour week is the rule rather than the exception. And this doesn't include traveling time! They are able to sacrifice almost every other value in life for their careers. Their wives know this, and many learn how to accept it.

Another quality of these men is that they are action-oriented. They are interested in the practical and immediate results, and they can make accurate and realistic decisions. They do not hesitate for long. But they could not be called snap-decision makers. They get the facts and integrate them, but they do not waste time. Moreover, they do not get entangled in details. Indeed, they are impatient with details. With a central goal clearly in mind, they are constantly driving for that goal.



NOW let us see how engineers fit this profile.

Luckily we have considerable information about mechanical engineers from a study by Harrison, Tomblen, and Jackson. The results were published in the magazine *Personnel Psychology* in 1955.

Mechanical engineers are intelligent. They stand well above the average of the general population.

They are not "odd balls." Emotionally, they are

as stable as any other group.

Except for research engineers, they are practical and action-oriented. Mechanical engineers want to see results. The other side of this attitude is that they are not particularly diplomatic. Their typical attitude is, "Let's stop all this fiddling around and get something done."

Mechanical engineers are quite conventional. They tend to be conservative in political outlook and are not likely to be regarded as radical or even liberal.

They need and want a definite structure. They do not like vague and ambiguous situations. They want a world that is clear-cut and definite. And apparently for this reason, they are likely to be somewhat autocratic. They favor giving a boss clear-cut authority, and they expect subordinates to obey. Participative management is likely to be regarded as a lot of hot air.

With this background, let us turn to the human relations of engineers. They are somewhat different from those of people in other professional fields. In general, engineers get along with other people pretty well. They do not want trouble, and they do not like conflict. Their relationships tend to be rather impersonal and somewhat casual. They prefer to settle things among people on what they would call a factual basis, and they are likely to regard feelings as avoidable distractions.

Probably an engineer can fall in love, but with the passage of time he is glad that kind of foolishness is over and he can settle down to tangible facts. Humans have to exist, he knows, but they are quite a nuisance, too.

Mechanical engineers don't care much about figuring out why people do what they do. They take folks as they seem to be and are not likely to dig below the surface. They deal with themselves the same way; they are not interested in self-examination. And because of their lack of interest in the analysis of other people, and the avoidance of self-examination, they often have rather shallow insight. They do not know, for the most part, what activates them. They can tell when they are clearly angry, and they can tell when they are definitely depressed, but more often they are not aware of more subtle behavior.

These facts, it seems to me, are particularly significant in considering the future of an engineer. A large part of the skills of an effective manager consists of the ability to understand, stimulate, and co-ordinate people. And these skills, in turn, are based upon insight and a sensitive interpretation of the behavior of others.

What about the leisure-time interests of engineers? Mechanical engineers are among the most masculine of all professional people in their interests. They are primarily interested in sports, and they like an active, outdoor life. They enjoy hunting and tramping around outside.

When it comes to reading, after winter forces them indoors, they take to adventure, historical novels, and action stories. Furthermore, they are likely to spend a good share of their reading time on mechanical and technical material. Their dominant interest in their own technical subject matter stays with them day after day.

Moreover, they are usually indifferent to the social sciences. They don't care much for sociology, and they care less for psychology. They didn't take those courses in college, and if they did happen to get into one by mistake, they were glad when they got out of it. So far as an engineer can see, these studies deal with many intangibles that do not really get the world's work done.

As a group, mechanical engineers are not particularly interested in music or art. They are somewhat more interested in plays, perhaps because of the visible action of the stage. But, for many of them music and painting seem too thin for their red-bloodedness.

HOW do all these things fit the requirements needed by a manager, a salesman, or a consultant? The needed intelligence is obviously there and so is the emotional stability. The engineer has also the practical quality of desire for direct action. His desire for definite structure may or may not handicap him depending upon the particular job he takes.

But when it comes to human relations, things are different. The engineer lacks what the salesman and the expert manager constantly depend upon—sensitivity to people. The manager must know what can be expected of a person, how to encourage this one, and how to slap that one down appropriately.

In the final analysis a manager must be a leader of people, for he has nothing if he cannot lead the team he has assembled. The essence of management is delegation and co-ordination of effort, and the man who does not know how to develop people and how to entrust tasks to them is no manager. This requires skill in sizing up and meeting social situations and people.

Another serious handicap for engineers in management is their low verbal interest and, I should add, low verbal achievement. Tests given to engineers often reveal poor grammar, awkward sentence structure, and misuse of words. Their competence in their native language is well below what we usually expect from people of their intelligence and their education.

Why is this? They simply don't care enough about words. True, they are interested in precision, but

it is the precision of expression that is possible through mathematics and drawings. Yet management, sales, and consulting require facility in verbal communication, in the ability to handle language graceful and adequately.

Although the engineer has certain characteristics that suit him for management, this brief survey shows some of the reasons why he lacks others. Some of the needed skills can be developed by appropriate training. But usually it is simpler to select engineers who already have the necessary qualifications. Fortunately, a fair number of engineers do not fit into the common pattern just sketched. Some of them do have excellent leadership skills and verbal facility. When asked to help select managers from the engineering group, we as psychologists search for qualities such as these rather than for excellence in engineering.

FOREGOING generalizations, of course, must be qualified. For one thing, there are rather wide variations in the human requirements of many management positions. Some, concerned primarily with factual decision-making, do not demand much in the way of leadership skills. Others require great tact and insight into people. A man who would fit the second kind would probably be unhappy in the first kind of position. A sales manager is not quite the same as a production manager, even when they are in the same company.

There is another qualification I want to make. I may have given the impression that in selecting managers, we need only be sure that a few specific qualities are present and we have our man. That is far from true. Psychologists have learned, from painful experience, that human personality cannot be compressed into a simple set of numbers.

There is a pattern to personality. Two men may be equally dominant, for example, but create totally different impressions. If the one is dominant and emotionally expressive, he gets along with people differently from the one who is dominant and coldly calculating. In the last analysis, then, the psychologist tries to understand as much as he can about the pattern of personality. Test scores and interviews are only means to that end.

I have pointed out that, as a rule, the kind of personalities that dispose men to choose engineering are not well suited for the usual roads to advancement in business and industrial organizations. The fact that a man is bright, hard-working, honest, and well-trained does not mean he is a good risk for management or sales.

Does this mean that engineers must accept their lot in organization life and resign themselves to little more than an occasional pay raise? Yes, for most, I think such a future is probable. But that does not mean that there are no rewards in it. "The American dream" of success is not the only pattern for living.

There are engineers for whom success is a matter of perfecting their skills and growing in knowledge. There are others whose success must be defined in terms of contributions to their communities and their families. And still others will find the rewards of life lie in teaching and stimulating students. It would be a mistake for all these people to accept the common measures of success as the gage of their stature.

An uncritical adherence to "the American dream" may lead good engineers to become mediocre managers and to waste their technical excellence. Some companies are preventing this by setting up positions that command respect and high income for scientific and technical excellence. These plans may encourage engineers to seek their satisfactions in engineering.

To those who have a persisting itch to enter management, I would make several suggestions. One is that you carefully evaluate your ability to use written and spoken English. Write an autobiography and have someone who knows writing examine it. Ask a close friend about his opinion of your clarity and fluency in conversation. If remedial steps are indicated, take them.

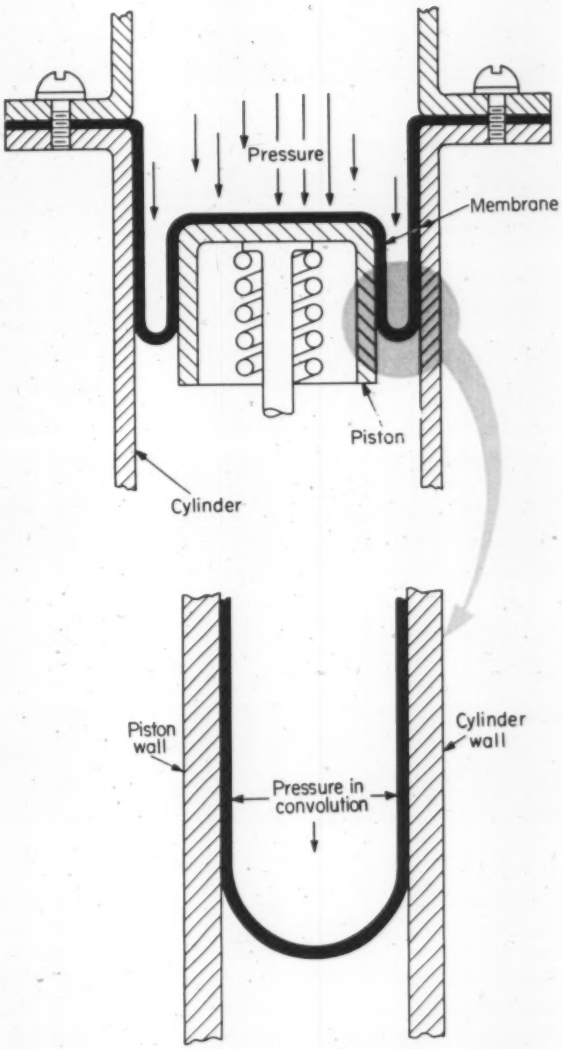
The second suggestion is harder to apply: Learn to improve your human relations. In part, this can be accomplished by reading which leads to increased understanding of people and personalities. But reading is not enough. Training is needed, and that cannot be obtained from reading alone. Unfortunately, most human-relations training courses rely too heavily on books and lectures instead of helping people discover their own style of behavior. Good human-relations training must deal directly with the trainee and aid his insight into himself, and this is often loaded with emotion.

In the past 15 years, we have learned a great deal about how to train people effectively by new methods. Some few industrial firms have offered their employees such training, but it has not yet won wide spread acceptance, Some summer institutes are available for individuals, but many engineers, of course, are not in a position to take advantage of them. Alternatively, committees in community organizations can be good training grounds. Trying to understand what makes them tick and learning to help them operate better can develop human-relations skills.

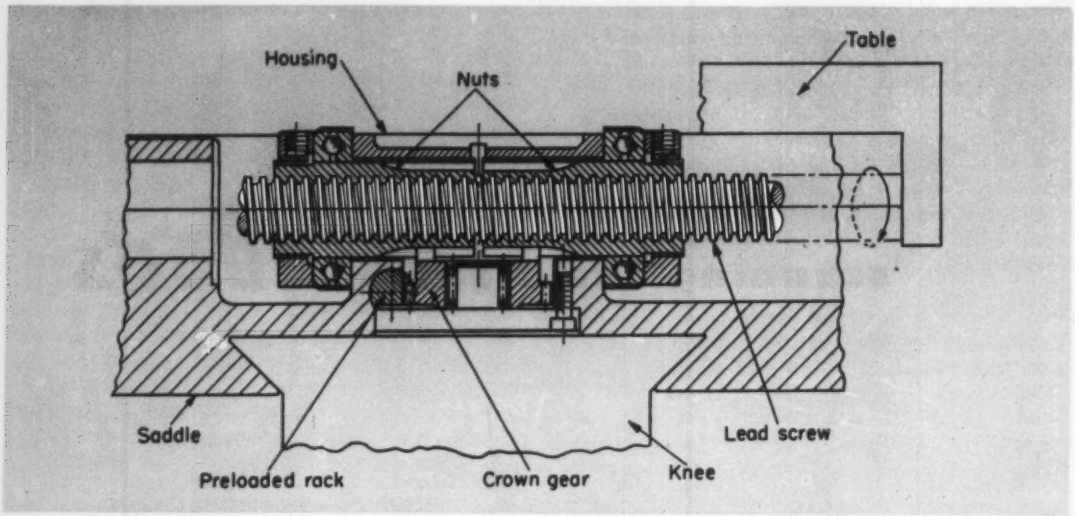
ACKNOWLEDGMENT

This article is based on a talk presented at the Fifth Conference on Mechanisms, cosponsored by Purdue University and MACHINE DESIGN, October 13-14, 1958.

scanning the field for *ideas*

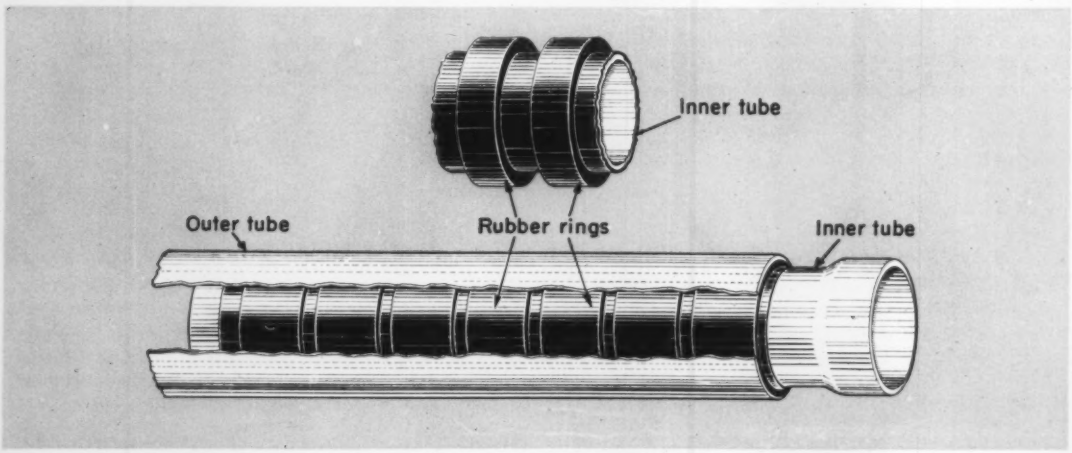


Peel-back membrane seal reduces friction and provides leak tight sealing between piston and cylinder. As piston moves up in cylinder, the membrane forms a convolution between cylinder and piston walls. Although most of the applied pressure load is supported by the piston head, some pressure acts on the convolution, forcing the outer wall of the membrane against the cylinder wall and the inner wall of the membrane against the piston sidewall. Reported by A. B. Palmer, this principle is used in the Bellofram designed by John Taplin.



Counter-rotating nuts in a power screw drive control backlash properties automatically in response to varying force and motion conditions. In a milling machine designed by Cincinnati Milling Machine Co., two nuts with exterior gear teeth are freely mounted on the table lead screw. A preloaded crown gear meshes with the exterior teeth on the nuts. When cutting forces act in the direction of table travel, frictional torque exerted on the trailing nut causes it to rotate with the screw. Rotation of the trailing nut drives the crown gear to rotate the lead nut in the opposite direction. A snug engagement of both nuts with the screw is developed, eliminating backlash. When other force conditions are imposed on the table, the preloaded crown gear acts to relieve the frictional torque on the trailing nut and the lead nut operates as the drive connection between the screw and table.

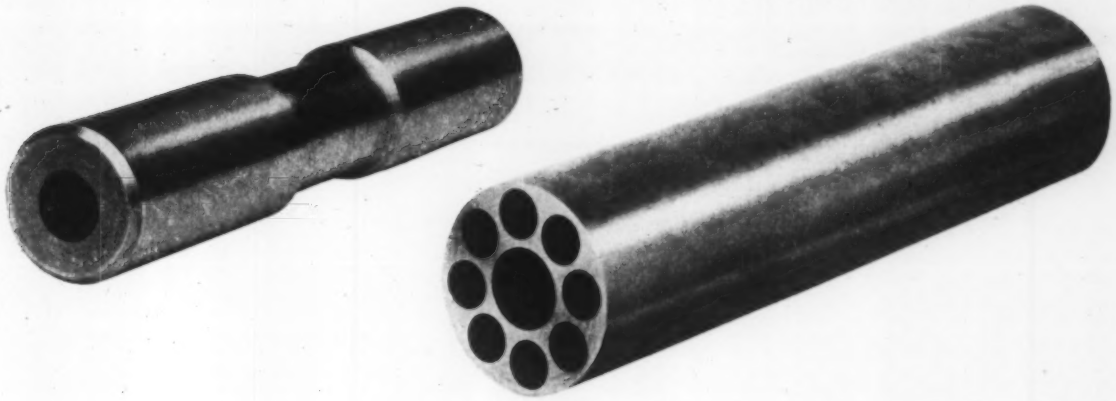
Rubberized drive shaft damps vibrations and reduces noises in hollow torque tube assembly. As employed on Chrysler Imperial, the propeller shaft is made of two concentric tubes. A series of seven rubber rings is bonded to the inner tube, and the assembly is forced into a larger outer tube. The rubber rings are compressed tightly enough to transmit driving torque, but retain sufficient flexibility and damping characteristics to absorb transmitted vibration and noise.



Aircraft pin, 5½ in. long, deep-drilled through in one pass. Material is modified 4330 steel, Rockwell C 35-40. The ½-in. diam hole was drilled concentric to the OD within 0.005 in. TIR. Finish obtained by deep drilling is 60-100 microinches rms. Reaming and honing, previously required, were eliminated.

Stainless-steel injection cylinder, 8 in. long. The center bore, 0.625/0.622 in., and outer holes, 0.378/0.375 in., were deep-drilled to obtain a finish under 60 microinches rms. A former boring operation was eliminated by deep drilling, and only light honing was required to provide a slip fit between the center bore and mating plunger.

Photos, courtesy Deep Hole Specialists Inc., Chagrin Falls, Ohio



Deep-Hole Drilling . . .

a practical design guide to the process, its applications, and design requirements,

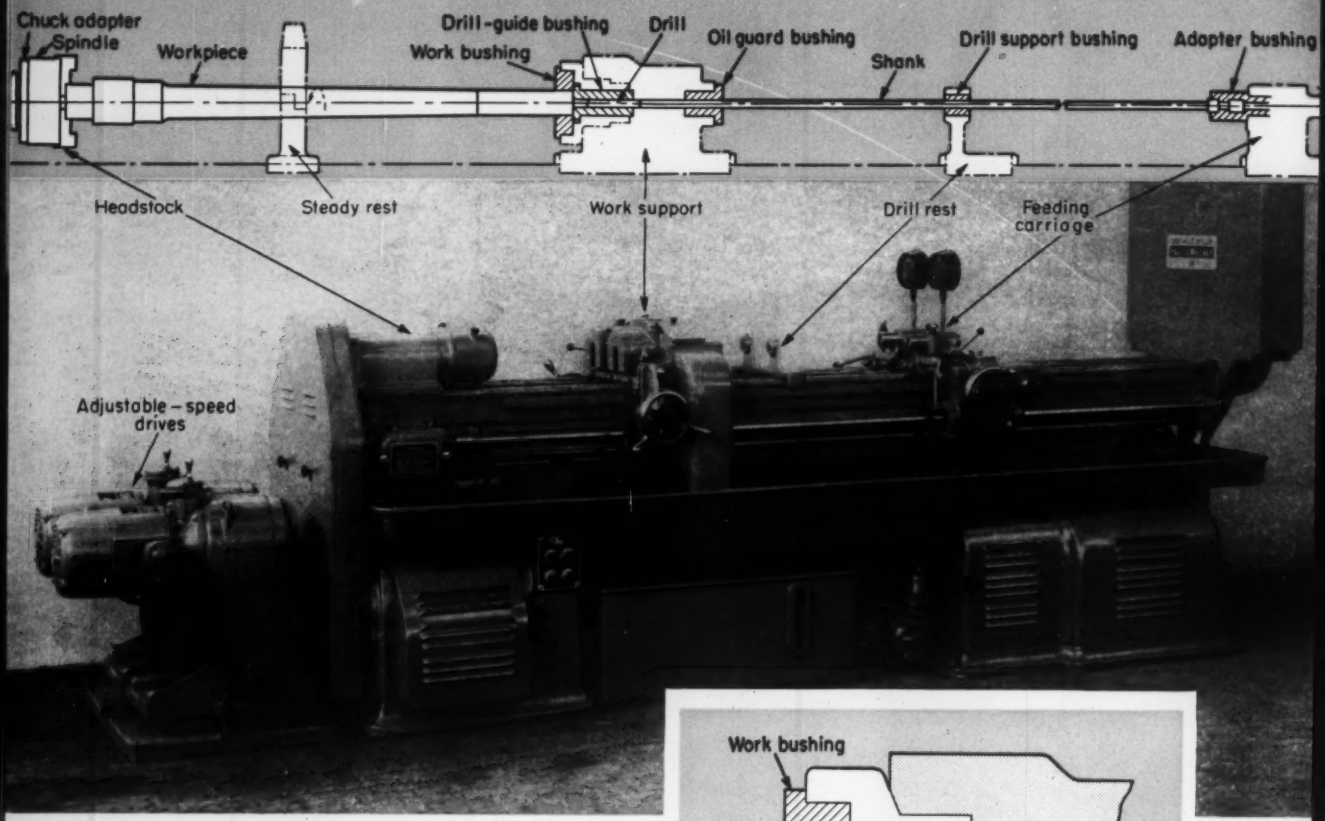
By JOHN C. DIXON
Pratt & Whitney Co. Inc.
West Hartford, Conn.

DEEP-HOLE drilling is generally specified to produce true holes to depths and tolerances not obtainable with ordinary twist drills. Depths from six diameters to more than 130 in. are possible in a single, uninterrupted operation where diameters do not exceed 2 in. Shallow holes which require a fine finish can often be completed by deep-hole drilling without subsequent reaming or honing operations.

Holes larger than 2 in. in diameter, and of moderate or great depth, can be trepanned more economically. But, where blind holes are concerned, a special parting tool is required to remove the core produced by trepanning.

In general, deep drilling and trepanning are not competitive. Cost of blind or through holes is approximately the same for both processes except when a special shape is required at the bottom of the hole.

Fig. 1—Typical tooling generally furnished for deep-hole drilling, top. For production runs of parts requiring a wide variety of hole sizes and constant drill and feed changing, machines with adjustable-speed drives are available, bottom. Such a drive is of value where experimental work on a variety of materials is necessary to determine correct speeds and feeds



This is usually accomplished by a second operation independent of the method of producing the hole.

Deep drilling is suitable for handling large quantities of production parts. Several workpieces can be drilled simultaneously, and constant operator attention is not required. Once the drill is started, feed is seldom stopped until the hole is completed. Rate of penetration, however, is less with deep drills than with conventional twist drills.

When To Specify Deep Drilling: For some applications, seamless tubing or extrusions satisfy design requirements for long, hollow parts. However, if tubing of a required wall thickness, for example, is not available or is too costly to roll, and the required number of parts is not great enough to justify extrusion-die costs, then certain economies

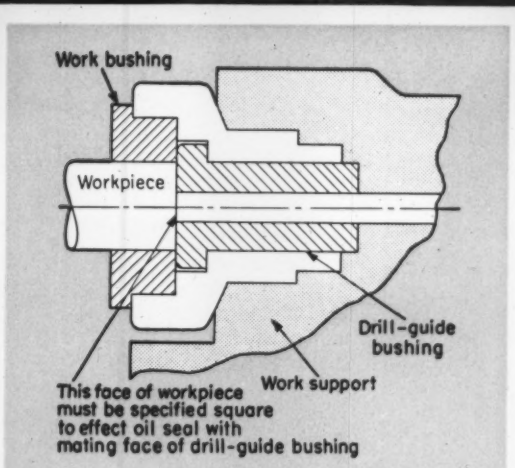

Work bushing
Workpiece
Drill-guide bushing
Work support
This face of workpiece must be specified square to effect oil seal with mating face of drill-guide bushing

Fig. 2—Contact of workpiece and drill-guide bushing. The mating faces of these pieces must form an oil seal capable of withstanding pressures to 1000 psi. The workpiece must be machined square to mate with the bushing and to provide a flat surface on which to start drill feed. If design of the part makes a square face impossible, the seal is formed by a bushing machined to the mating contour of the workpiece

can be realized by deep-drilling bar stock.

Carbide-tipped drills can deep-drill materials such as Stellite, stainless steels, and titanium which are so abrasive that use of high-speed steel drills is impractical.

Deep-hole drilling is not recommended for second-operation work. Some deep-drilling machines are equipped for reaming operations and, where greater accuracy and finer finish are required, tube reaming should follow drilling. Applications requiring recessed or relieved holes are not practical for deep drilling.

How Deep Drilling Is Done: In most cases, the work is rotated between the headstock and work support of a machine designed for the purpose, Fig. 1. The stationary drill, a single-lip boring tool on a hollow steel shank, is fed against the rotating workpiece and is guided by a bushing contacting the work. A coolant, fed through the shank, lubricates the drill tip and flushes away chips to prevent marring the hole finish.

The workpiece must be machined square on the

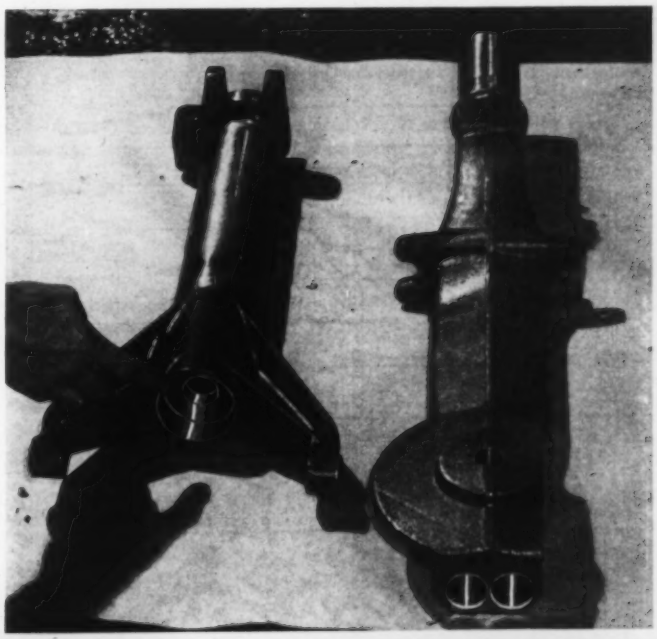


Fig. 3 — Right — Landing-gear parts which have been deep drilled. Unsymmetrical parts, such as these forgings, require balancing if they are to be rotated. The part on the right required a special balance fixture because of the sharp bend (visible in Fig. 4). Note wall thickness between parallel holes

Fig. 4 — Below — Landing-gear forging in fixture which is dynamically balanced. The fixture is necessary to prevent drill runout

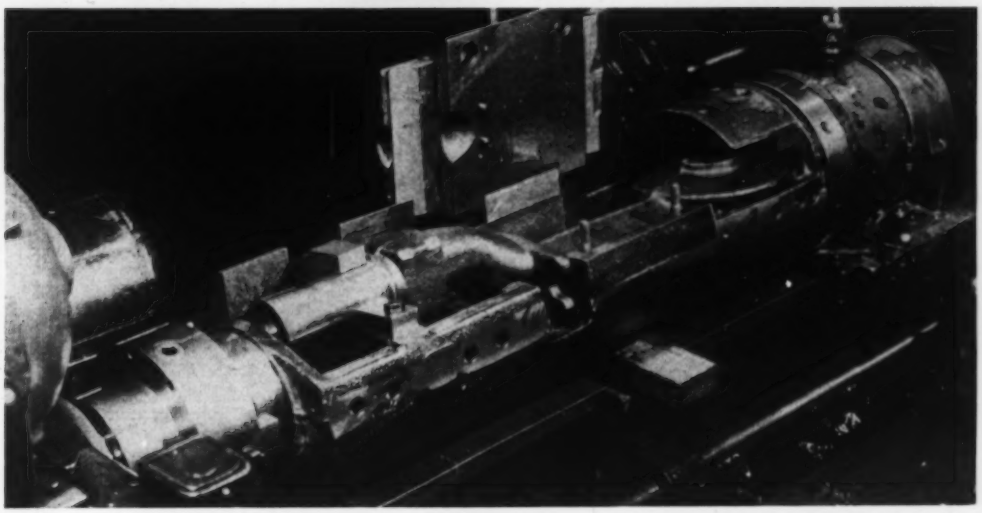
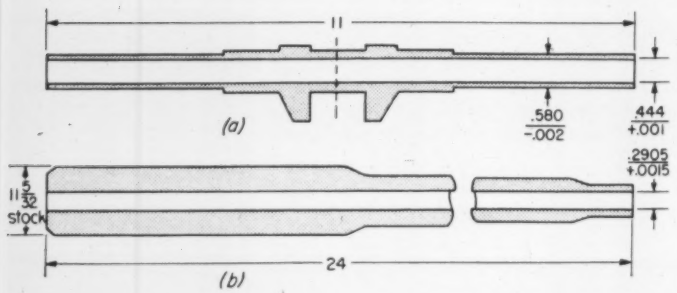
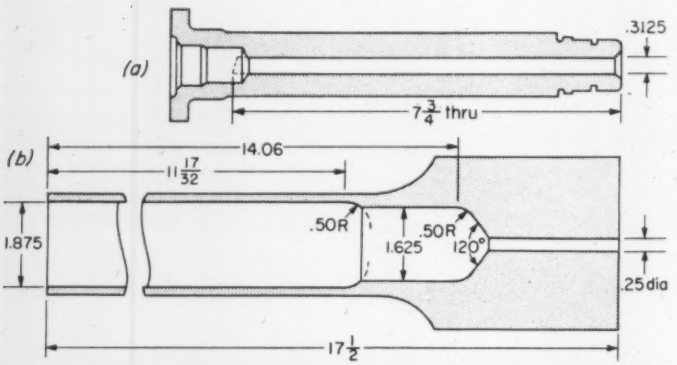


Fig. 5
Design Tips for Deep-Drilling Applications



Through Holes

Gun barrels typify parts suitable for deep drilling. Pistol barrels, *a*, for 45-caliber automatics, start as a single forging. After deep drilling, the forging is cut in half to produce the barrels. Note wall thickness. The chrome-molybdenum rifle barrel, *b*, is drilled through to dimensions shown. Here, permissible eccentricity of the bore over the 2-ft length ranges from 0.005 in. at the breech end to 0.060 in. at the muzzle end through 360-deg barrel rotation. A subsequent reaming operation opens the bore approximately 0.008 in.

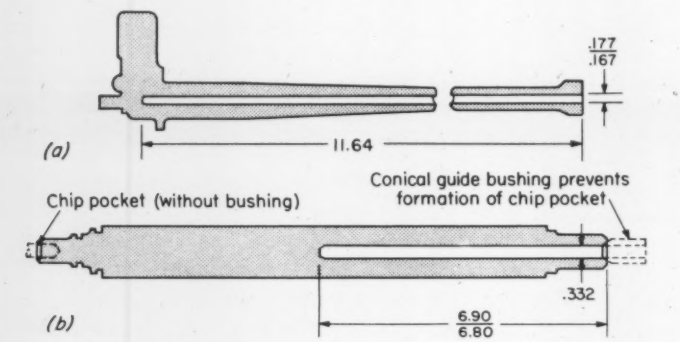


Sketch *b*, courtesy Deep Hole Specialists Inc., Chagrin Falls, Ohio

Stepped Holes

Aircraft part deep-drilled on a vertical, multiple-spindle machine, *a*, shows the hole meeting an existing bore in the part. The aircraft rod of ASM 6407 steel, *b*, was produced in three operations. The 0.25-in. diam hole was first deep-drilled through the 17½-in. length. Tube reaming formed the 1.875-in. diam hole and the 0.5-in. radius in the same operation. The 1.625-in. diameter was tube reamed using a long starting bushing in the large bore to maintain concentricity within 0.005 in. TIR. The 0.5-in. rad and 120-deg angle were produced with the form-ground tube reamer.

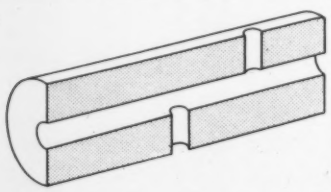
Generally, for accurate stepped holes, the large hole is drilled first. If the difference in diameters is ¼ in. or more, a bushing is used to guide the drill for the small hole. If the difference in diameters is less than ¼ in., the small hole is drilled through first and opened to size with a tube reamer.



Blind Holes

Stainless-steel afterburner nozzle, *a*, shows a blind hole deep-drilled to a specified depth. Tolerance on the required depth is ±0.010 in. The bore must be concentric to three OD's within 0.010 TIR. Aircraft part, *b*, is deep-drilled to within 0.005 in. of a certain depth. The part is later reversed in the machine, and a second blind hole is drilled to within 0.720 in. of the first.

If centers of a larger diameter than the drill size are required in a workpiece, they should be made large enough to accommodate a conical drill-guide bushing as shown at the right of part *b*. Without a guide bushing, a chip pocket is formed between the drill and center chamfer as shown at the left.



Cross Holes

Valve bodies and manifolds which require intersecting or cross holes should be deep drilled before adding the cross holes, if possible. Since the deep drill is force lubricated through the tip, a pressure-tight bore must be maintained. If cross holes are present, they must be plugged to prevent escape of coolant.

surface which contacts the drill-guide bushing, located in the work support, Fig. 2. This is necessary to effect an oil seal between the parts capable of withstanding coolant pressure to 1000 psi. Where carbide drills are used, the bushing itself is usually carbide, or at least contains a carbide or graphmo insert, to withstand drill wear on the bore.

Materials: Practically any material that can be machined with high-speed steel or carbide-tipped tools can be deep-drilled. The usual machinability ratings for milling, turning, and conventional drilling are applicable. Longer tool life and better finishes are achieved with materials having a spheroidal structure.

For best results, hardness of the workpiece should not exceed 320 Bhn. Materials as hard as 375 Bhn can be deep-drilled but at the expense of tool life. Deep-hole drills of high-speed steel are run at approximately twice the speed of twist drills of the same material, and carbide-tipped gun drills are run at four to six times the speed.

Soft "leady" materials tend to tear, and it is well to normalize the part for improved grain structure.

Size and Shape of Workpieces: Round bar stock and symmetrical forgings are typical of the majority of workpieces deep-drilled. However, unsymmetrical parts also lend themselves to the process, Fig. 3. If such parts are to be rotated, they must themselves be balanced of placed in a fixture which can be dynamically balanced to prevent drill runout, Fig. 4. If the shape cannot be handled in such a fixture, then it can probably be deep-drilled on a type of machine which holds the work stationary and rotates the drill instead.

Other parts suitable for deep drilling include gun barrels, camshafts, crankshafts, machine-tool spindles, automotive and aircraft valves, valve-stem guides, gun-barrel liners, machine components, connecting rods, and stay bolts.

Blind holes to specified depths, stepped holes, and through holes can be deep-drilled in such parts, Fig. 5. Secondary operations are required for special bottom shapes in blind holes. For accurate stepped holes, drill-guide bushings are sometimes necessary.

Hole Size and Maximum Depth: A practical maximum depth for holes 3/16 in. in diameter or under is 100 diameters. Maximum-depth holes are generally specified straight within 0.002 in. per 10 in. of depth, but the hole may not be concentric with the OD.

Sizes of maximum-depth holes which have been deep-drilled successfully include $\frac{5}{8}$-in. diam holes to a depth of 50 in. and more, and $1\frac{1}{8}$-in. diam holes to 98 in. deep. The longest hole that can be drilled on a 2-in. capacity machine is 105 in. Longer workpieces require special equipment.

Tolerances and Finish: With deep-hole drilling, runout of approximately 0.0005 in. per inch of depth is possible. Although many holes show less, the maximum possibility should be considered and allowed for in design. Where concentricity is critical, the hole can be drilled first and the OD machined concentric to the bore.

The general tolerance on hole diameters is 0.002 in. for most materials. This allows for the difference in diameters of new and worn drills. Excessively long holes may become tapered due to rubbing on the drill shank. Tolerances as small as 0.0005 in. are held feasible by some vendors, but such tolerances are obtained only on relatively shallow holes in free-machining steels.

Finishes of approximately 65 microinches rms are produced by deep drilling. For finer finishes, reaming or honing is recommended.

Oscillating-Load Bearings

In "Oscillating-Load Bearings" by Donald J. Myatt, December 11, 1958, the definition of journal eccentricity following Equation 1 is incorrect. Eccentricity is correctly defined $\varepsilon = 1 - h_0/c$. The incorrect expression for eccentricity was applied in the Example.

Also, correct calculation for minimum oil-film thickness in the Example should be: $h_0 = 2 \times 7 \times (5 + 32) = 518$ mu in. Safe load time results, Table 4, are correct if $h_0 = 0.000449/2 = 0.000224$ in.

Tips and Techniques

Opposite-hand Lettering

When upside-down prints are traced to obtain opposite-hand drawings, reading letters or numbers can be a tedious job. To simplify the procedure, an ordinary mirror is held edgewise on the upside-down print. The letters or numbers appear right side up.—E. J. Kick, *Tonawanda, N. Y.*

Evaluating Z = e^x

To evaluate the expression $Z = e^x$, where e is the base of natural logarithms, without the use of tables or log log slide rule; multiply x by 0.4343. The antilog of the product, $0.4343x$, to the base 10 is equal to the value of Z.—Jesse Roth, *electrical engineer, Milwaukee, Wisconsin.*

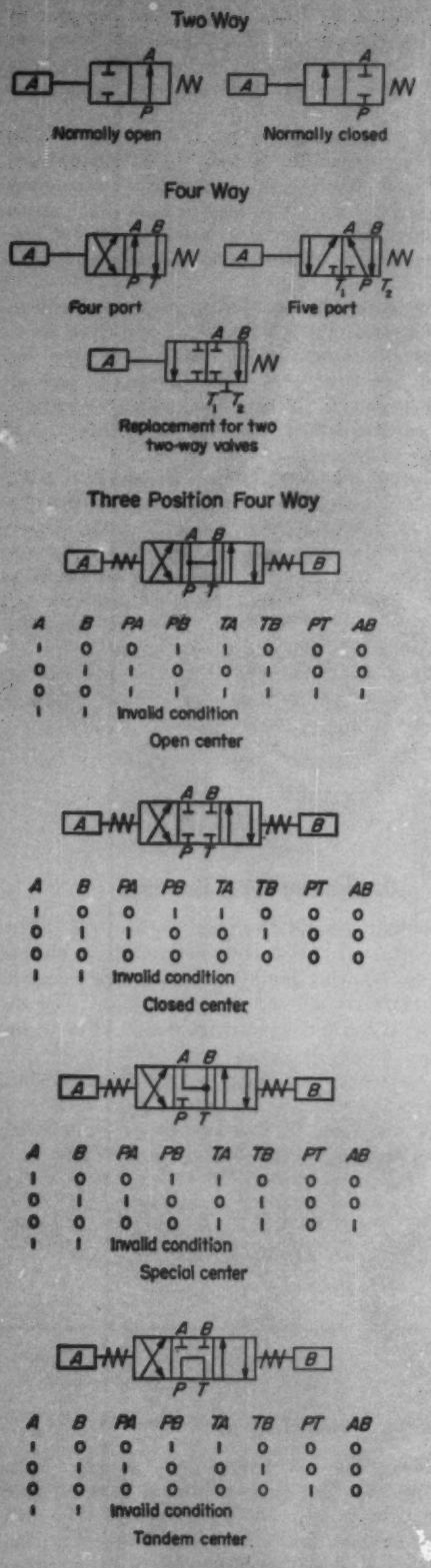

Two Way
Normally open
Normally closed
Four Way
Four port
Five port
Replacement for two two-way valves
Three Position Four Way
A B PA PB TA TB PT AB
1 0 0 1 1 0 0 0
0 1 1 0 0 1 0 0
0 0 1 1 1 1 1 1
1 1 Invalid condition
Open center
A B PA PB TA TB PT AB
1 0 0 1 1 0 0 0
0 1 1 0 0 1 0 0
0 0 0 0 0 0 0 0
1 1 Invalid condition
Closed center
A B PA PB TA TB PT AB
1 0 0 1 1 0 0 0
0 1 1 0 0 1 0 0
0 0 0 0 1 1 0 1
1 1 Invalid condition
Special center
A B PA PB TA TB PT AB
1 0 0 1 1 0 0 0
0 1 1 0 0 1 0 0
0 0 0 0 0 0 1 0
1 1 Invalid condition
Tandem center

Fig. 8—Spool valves

HYDRAULIC

Part 2 —

By HAROLD R. RONAN Jr.
Research Engineer
Gould and Eberhardt Inc.
Irvington, N. J.

The first part of this article outlined the fundamentals and applications of logic functions in control-circuit synthesis. Here, in the concluding installment, components and elements for complex circuits are expressed in terms of the logic functions. These logic equivalents permit the designer to select the right components to fulfill required output conditions.

SWITCHING CIRCUITS

Spool-Valve Equivalents and Special Circuit Elements

CIRCUIT designers, armed with a working knowledge of switching techniques, need not depend upon devices other than hydraulic to perform the "thought" processes of a hydraulic circuit. Unfortunately there is a major impasse to the design of a completely hydraulic control for systems of more than average complexity. Performance of logic functions in a circuit require the use of many additional valves. Commercial valves are limited in the types available and have a tendency to be large because of flow-rate requirements. As a result, they are relatively expensive compared to their relay counterparts.

If the designer has recourse to hydraulic components designed solely for control intelligence, there would be little restriction on what could be done economically. These valves could be compact and inexpensive with nominal pressure ratings.

▶ Spool-Valve Equivalents

As an aid to taking full advantage of available components, algebraic expressions can be evolved for the more common spool valves.

Two-Way Valves: The simplest of the spool valves, the two-way, spring-return spool valve is of either the normally open or normally closed type, Fig. 8. The switching equation for the normally open type is

$$f(PA) = A'$$

and for the normally closed type,

$$f(PA) = A$$

Four-Way Valves: There are generally two types of four-way valves, four port and five port, Fig. 8. The four-port type is the most common and the switching notations for this valve are

$$f(PA) = A' \qquad f(PB) = A$$

$$f(TB) = A' \qquad f(TA) = A$$

For the five port valve,

$$f(PA) = A' \qquad f(PB) = A$$

$$f(T_2B) = A' \qquad f(T_1A) = A$$

The switching equations for both the four and five-port valves are the same, but the five-port valve has more flexibility. If the pressure port of the five-port valve is blocked, it can be used in place of a normally open and a normally closed two-way valve, provided the valve design allows pressure to be applied at the tank ports. These valves may be internally drained to the tank ports, which makes the pressure at these points functionally detrimental. Fig. 8 shows the symbol for a five-port, four-way valve that could be used in place of two two-way valves.

Three-Position Four-Way Valves: The spring-centered valve with open center, Fig. 8, is a three-state device. The switching equations for the output are obtained from the valve position tabulation.

$$f(TB) = f(PA) = (A' + B)(A' + B') = A'$$

$$f(TA) = f(PB) = (A + B')(A' + B') = B'$$

$$f(PT) = f(AB) = A' + B'$$

The condition when both A and B are energized is called invalid because it is a state avoided in circuit design. If the actuators A and B were solenoids, one or both would burn up if they were left on for any length of time. If the invalid condition is used, the port connections are

$$f(TB) = f(PA) = A'(A + B) = A'B$$

$$f(TA) = f(PB) = B'(A + B) = B'A$$

$$f(PT) = f(AB) = (A' + B')(A + B) = B'A + A'B$$

For the spring-centered valve with closed center, Fig. 8,

$$f(TB) = f(PA) = B + A'$$

$$f(TA) = f(PB) = A + B'$$

and with the invalid condition,

$$f(TB) = f(PA) = (B + A')(A + B) = B$$

$$f(TA) = f(PB) = (A + B')(A + B) = A$$

Hence, the output-port equations for the closed center valve are the negatives of the equations for

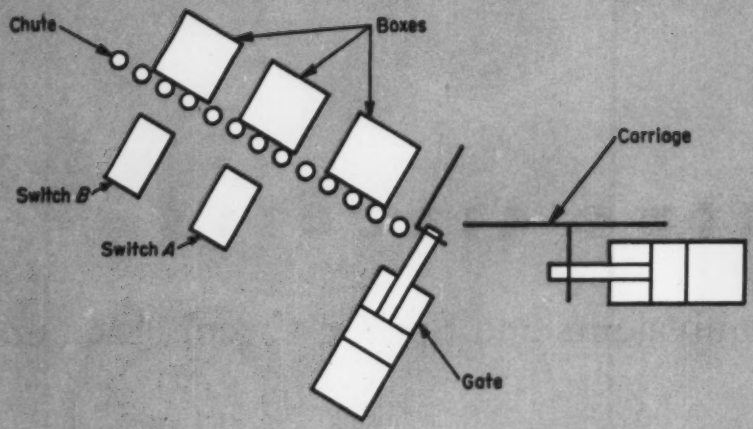


Fig. 9—
Problem schematic for conveyor

the open-center valve when the invalid conditions are considered.

For the spring centered valve with special center, Fig. 8,

$$f(PA) = A'B \qquad f(AB) = A' + B' \qquad f(PB) = B' + A$$

$$f(TA) = (A + B')(A' + B') = B'$$

$$f(TB) = (A' + B)(A' + B') = A'$$

and with the invalid condition,

$$f(PA) = (A' + B)(A + B) = B$$

$$f(PB) = (B' + A)(A + B) = A$$

$$f(TA) = B'(A + B) = AB' \qquad f(TB) = A'(A + B) = A'B$$

$$f(AB) = (A' + B')(A + B) = B'A + A'B$$

For the spring-centered valve with tandem center, Fig. 8,

$$f(TB) = f(PA) = A' + B \qquad f(TA) = f(PB) = A + B'$$

$$f(PT) = A' + B'$$

and with the invalid condition,

$$f(TB) = f(PA) = (A' + B)(A + B) = B$$

$$f(TA) = f(PB) = (A + B')(A + B) = A$$

$$f(PT) = (A' + B')(A + B) = B'A + A'B$$

▶ Memory Elements

A memory element is just what the name implies. It has the facility to remember a past state or, more precisely, a past signal. Every memory device must also incorporate the property of forgetting. The act of forgetting is accomplished by: Elapse of time, the magnitude of which is determined internally or externally, and change in state of an external element or elements.

The most common hydraulic memory unit is the two-position, double-operated directional valve without springs. The spool in this valve is shifted by an actuation signal at one end. After the removal of the signal, the spool remains in the shifted position until a reset signal at the opposite end appears. This type of valve is particularly useful in circuits which require automatic operation of a number of elements in a given sequence.

Sequential Circuit: The use of memory valves is best understood by illustration in a circuit problem. All circuits are evolved from a statement in words of what is to accomplished.

A section of transfer line is to be designed to load six boxes, three at a time, onto a carriage. The carriage carries them to another point in the line. The boxes are fed into an inclined chute which has a capacity of three boxes. A gate is held closed until three boxes are in the chute, at which time it opens and permits the boxes to slide down onto the carriage. Then the gate closes and is ready to receive the next group of boxes.

When three more boxes enter the chute, the gate opens and admits them to the carriage. At this point the carriage moves to the right, where the six boxes are removed, and the carriage returns. Removal of the boxes from the carriage is not to be considered. The problem is shown diagramatically in Fig. 9.

The first consideration in this design is the type and number of information inputs that control the operation of the circuit. This is important, since the choice dictates the course to be followed in completing the circuit. The number of boxes in the chute

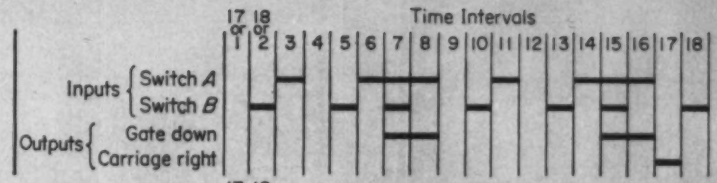


Fig. 10—Sequence diagram for conveyor with circuit inputs and desired outputs

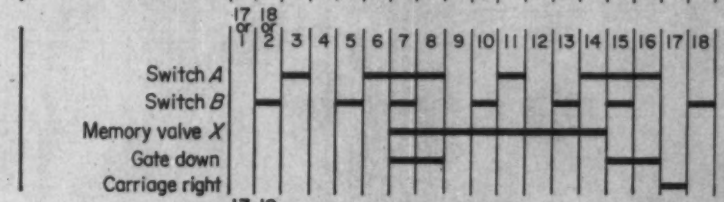


Fig. 11 — Sequence diagram of conveyor with memory valve incorporated. One valve does not give desired output

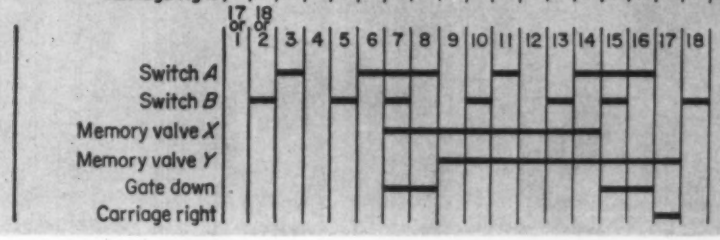


Fig. 12—Final sequence diagram for conveyor. Two memory valves give desired outputs

must be determined. Mechanically operated hydraulic valves will be used as limit switches for this purpose.

Although a first glance indicates that three limit switches are required, two switches are sufficient to indicate the presence of three boxes. Presence of only boxes 2 and 3, Fig. 9, is indicated by tripped switches. Permanent tripping of switch A can occur only if there is a box between A and the gate. The manner in which switches A and B are tripped by the boxes is shown graphically in Fig. 10, along with the desired outputs.

This type of sequence diagram is constructed by drawing in time intervals along a horizontal axis, and inputs and outputs along the vertical axis. The time intervals may or may not represent an exact length of time. In this case no particular time is implied. When an input or output is present in a given time interval, it is shown by a horizontal bar or line. Hence, when the sequence chart is read from left to right, the order in which elements occur is evident. An important characteristic of this type of diagram is that the vertical columns show immediately the combinations of inputs required for any outputs in the required intervals. Time intervals 7, 8, 15 and 16 yield the following inputs to move the gate down: Interval $7 = A + B$, interval $8 = A + B'$, interval $15 = A + B$, and interval $16 = A + B'$. Hence,

$$f(\text{gate down}) = (A + B)(A + B')(A + B)(A + B')$$

$$f(\text{gate down}) = (A + B)(A + B') = A$$

Operation of switch A causes the gate to go down in the indicated intervals, but it also operates the gate in time intervals 3, 6, 11, 13, and 14. This condition is not acceptable, and indicates that there is an insufficient number of inputs to give the output only in the desired intervals. In other words, intervals 7, 8, 15, and 16 are not unique or do not yield unique input combinations.

The same situation is true for the carriage output, where $A' + B'$ not only occurs in the desired interval 17, but also in intervals 4, 9, and 12.

Therefore, additional elements are needed to record the passage of events such that combinations available for outputs are unique. Hence, memory valves are introduced.

The next problem is to choose the operate and release intervals for the memory valve. In Fig. 11, this has been done for a valve designated as X. The operate is interval 7 and the release is interval 15. These intervals are far from satisfactory, however,

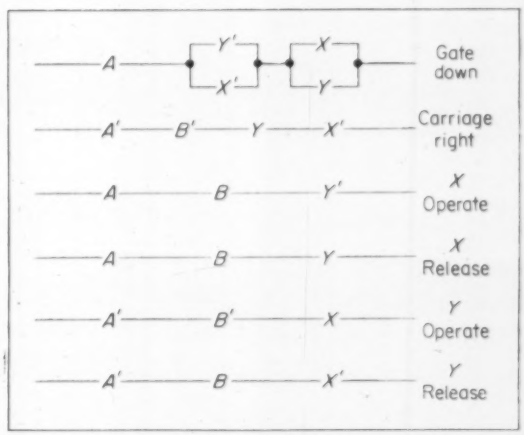


Fig. 13—Diagram for elimination of unnecessary circuit paths

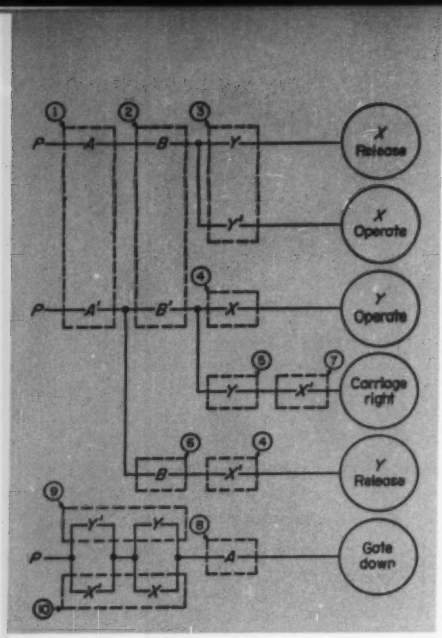


Fig. 14—Diagram for circuit component determination

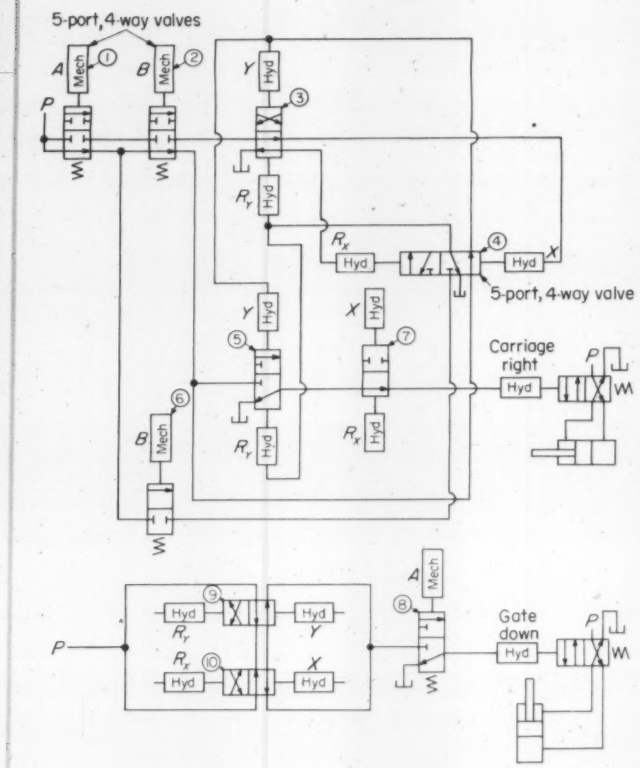


Fig. 15—Final circuit schematic for conveyor

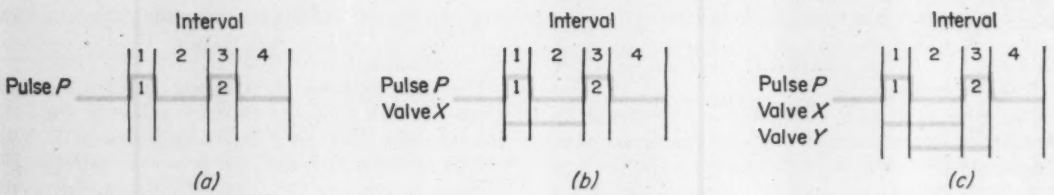


Fig. 16—Two-pulse counter. Sequence diagrams show, *a*, two pulses; *b*, inability of one valve to count pulses; *c*, final two-pulse counter sequence

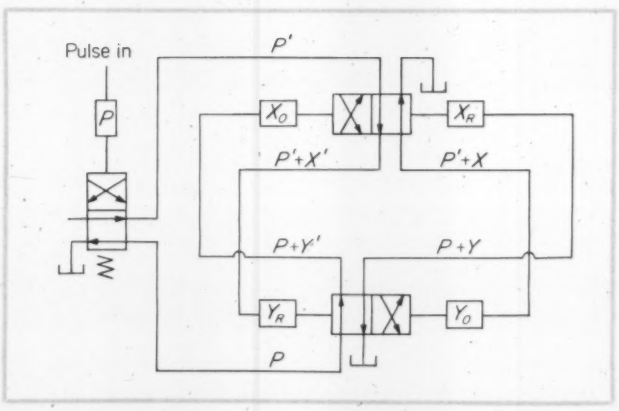
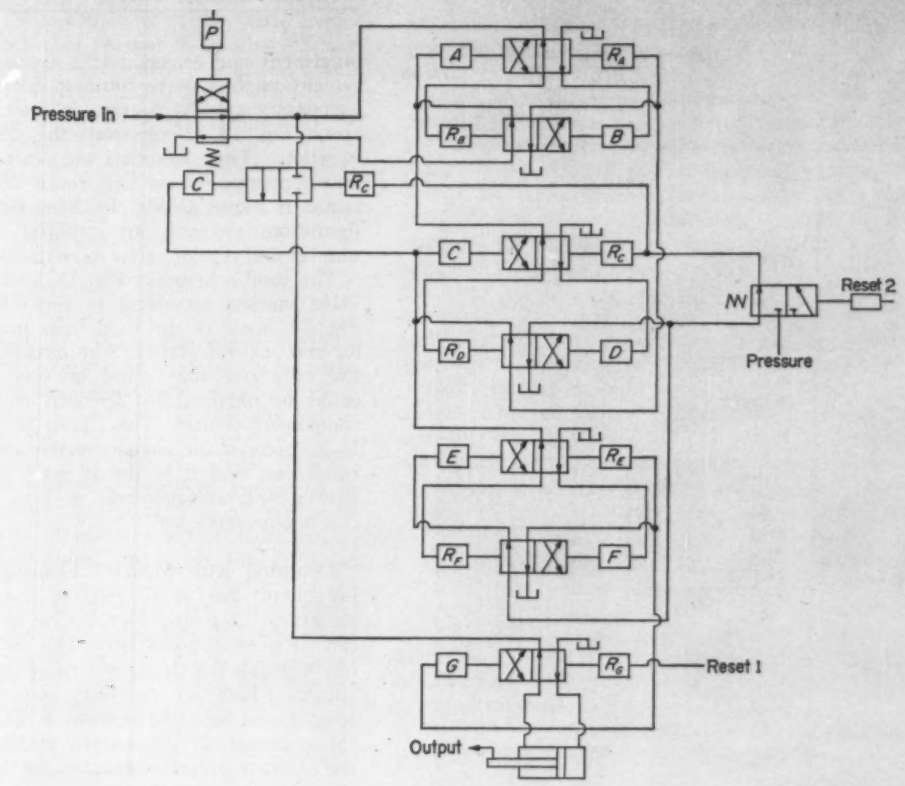


Fig. 17—Two-pulse counter schematic



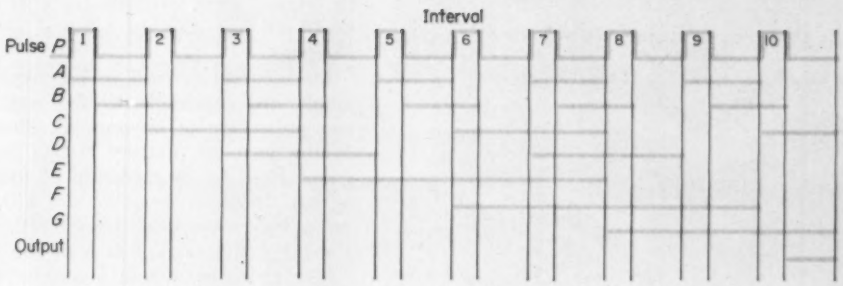


Fig. 18— Hydraulic decade counter

because the combination for release is the same as that for operate. Other choices for operate and release lead to equally unsatisfactory results. Therefore, another memory valve is used. This additional valve is designated as Y.

Fig. 12 shows that combinations of A, B, X, and Y are unique for the desired outputs and yield a satisfactory circuit. Also, proper internal control of each valve is obtained by using Y in the operate and release of X, and vice versa. Although the X and Y valves are not directly related to some physical event, they are necessary to record recurrent combinations of A and B so that outputs are obtained only in specified time intervals.

From time intervals 7, 8, and 15 and 16, Fig. 12, combinations of X and Y in addition to A are obtained.

$$f(\text{gate down}) = A + (X + Y')(X' + Y) = A + Y'X' + XY$$

From interval 17,

$$f(\text{carriage}) = A' + B' + X' + Y$$

From intervals 7 and 15,

$$f(X \text{ operate}) = A + B + Y'$$

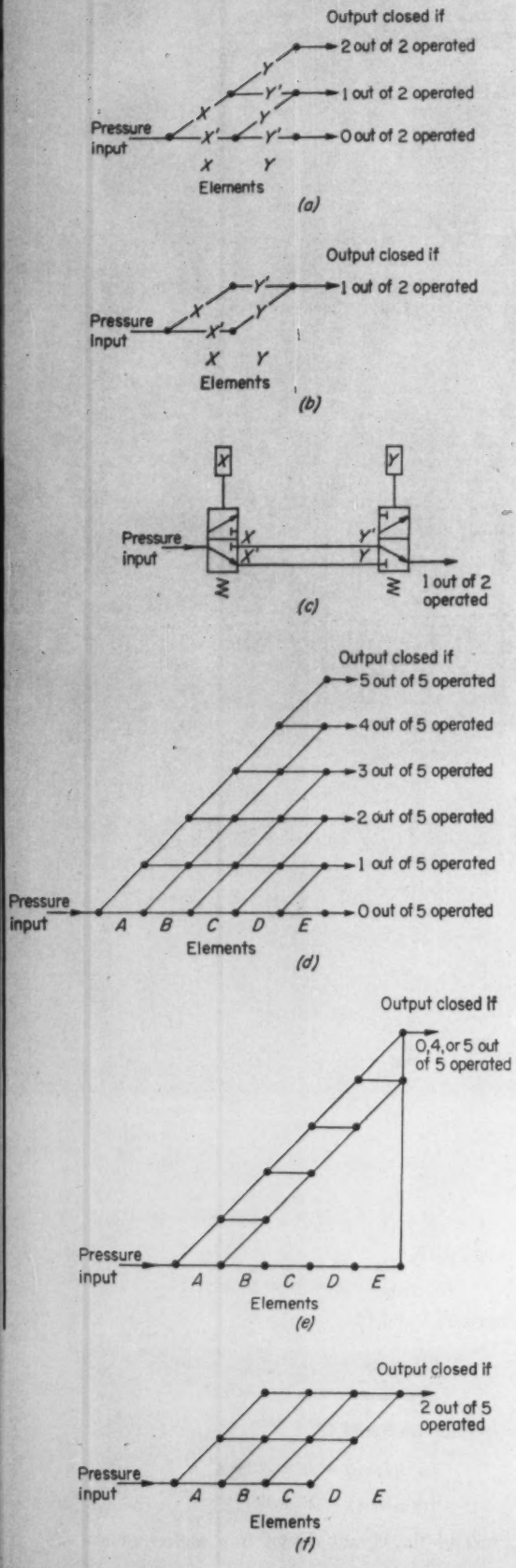
$$f(X \text{ release}) = A + B + Y$$

And from intervals 9 and 18,

$$f(Y \text{ operate}) = A' + B' + X$$

$$f(Y \text{ release}) = A' + B + X'$$

The rest of the circuit design is a matter of ar-



rangement and selection of components. As a convenient method of performing this final phase, an elementary circuit diagram is drawn in a vertical array, Fig. 13, to represent the derived switching equations. Then elements are rearranged to eliminate repetitive letters. One result that could be obtained is shown in Fig. 14. After settling on a configuration, elements are grouped to indicate the number and type of valves to be used.

The final schematic, Fig. 15, is drawn with each valve marked according to the selection made in Fig. 14. Some of the fluid lines have been omitted for the sake of clarity. The circuit, Fig. 15, is not the only one that could be used. Several others could be obtained by different manipulations and component choices. The choice of operate and release intervals for memory valves depends upon the conditions, and it is always good policy to investigate several arrangements so that a desirable circuit is not overlooked.

Counting with Memory Elements: Every counting circuit has as its purpose the recording of a succession of events so that the stored information can be used at some later time. A counting circuit has associated with it two, or in some cases three, circuits which are necessary, but not directly related to the counting process: 1. The pulse or event input circuit. 2. An output circuit, which makes use of the information supplied by the counter. 3. An external reset circuit, which restores the counter to its original state to count again. If the counters are made self-recycling, an external reset circuit is not necessary.

Memory valves used in the sequential-circuit example are applicable to the counting process. If two pulses are to be counted, these pulses will be in the form of pressure rises. The sequence diagram, Fig. 16*a*, is made up of four significant intervals. Intervals 1 and 3 are alike, and 2 and 4 are alike. Elements of this circuit must be added in a manner that makes each of the intervals unique.

The characteristics of a counter is that the states of the elements at any point in the counting process reveal number of pulses counted. In the natural sequence,a valve, X in Fig. 16*b*, is energized when the first pulse appears. An interval must then be chosen to de-energize this valve. Interval 2 is not a good choice because it adds no additional information. Therefore, the second pulse is used for resetting. Since

Fig. 19 — Symmetrical circuits. Diagrams show, *a*, generalized two element layout; *b*, one out of two elements operated; *c*, more natural construction of one out of two elements operated; *d*, generalized five element lavout; *e*, zero, four, or five out of five elements operated; *f*, two out of five elements operated

a valve cannot be operated with the same combination of elements that releases it, another element is required. The addition of valve Y, Fig. 16c, makes all four intervals unique. The operate and release conditions for valves X and Y are obtained by investigating each interval.

$$f(\text{X operate}) = P + Y'$$

$$f(\text{X release}) = P + Y$$

$$f(\text{Y operate}) = P' + X$$

$$f(\text{Y release}) = P + X' \qquad (11)$$

The circuit, Fig. 17, fulfills the requirements of Equation 11. This counter incorporates a four-way valve for the pulse input circuit and is self-recycling. If sufficient time is allowed to actuate the valves, the pulse length and the intervals between pulses can have any value. For counting larger numbers of pulses, simple two-pulse counters, connected in a cascade arrangement, are used. Two of these units count four pulses, three units count eight pulses, four units count 16 pulses, and so on. Fig. 18 shows a decade counter with an output at the end of the tenth pulse. Since this counter is not self-recycling, two external resets are necessary to return the counter to the normal state. Reset 1 must appear before reset 2, or the output cylinder will not return to its original position.

Symmetrical Circuits

A symmetrical circuit is an array of valves which will close a free-flow path for a specified number of valves out of a group. A simple symmetric circuit with two four-way valves was used in the gate-down control of the conveyor, Fig. 15. Valves 9 and 10 close a path if only one of two is operated.

There is a simple technique that generalizes the setup of the required circuit connections. Across the bottom of the connection diagram of a two-element symmetrical circuit, Fig. 19*a*, the two elements are written in. Above each element are the paths that each element controls. Horizontal connections are normally open or free-flow paths, while the slanted lines are normally closed or blocked-flow paths. At the right are the various outputs obtained for the individual states of the elements. From this generalized diagram, the desired outputs can be selected and the unnecessary connections deleted.

The resultant diagram for a one-out-of-two symmetrical circuit is shown in Fig. 19*b*. Correlation of this diagram with the choice of valves used in the conveyor circuit, Fig. 15, may be difficult because of the unusual connections. A more natural choice would be two three-way valves hooked up back to back, Fig. 19c.

The same technique may be extended to include any number of elements. For example, a five-element symmetrical circuit is shown in Fig. 19*d*. Selections possible from a general matrix are shown in Fig. 19*e* and 19*f*. An actual valve diagram for the two out of five circuit is shown in Fig. 20.

The symmetrical circuit is not just a curiosity. It can be used on the conveyor, Fig. 15, to check the position and alignment of boxes on the conveyor by operating an ejecting cylinder, to control traffic for conveyor feeders by preventing backup in any one line or lines, or to check the position of a number of manually operated valves by dumping the main pump delivery back to the tank.

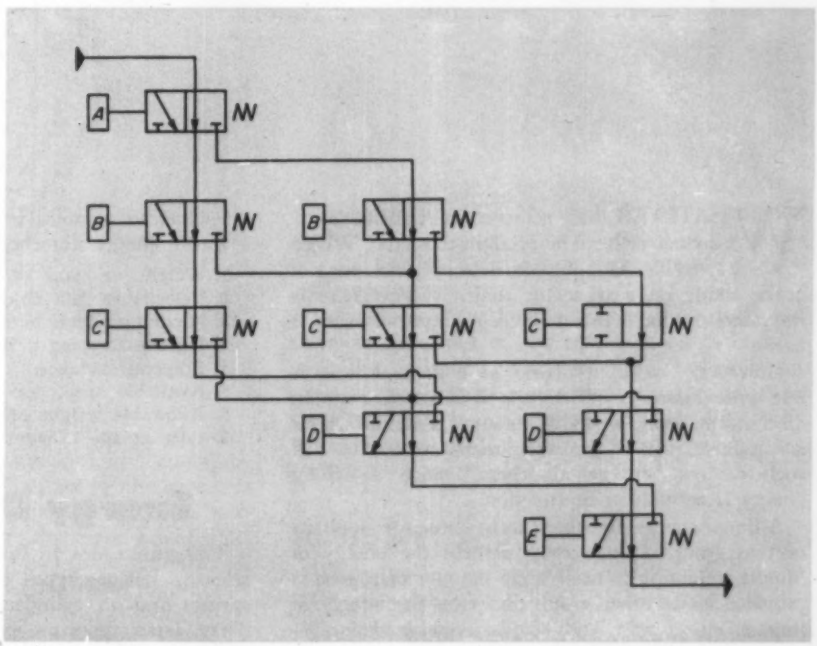


Fig. 20—Valve arrangement for two out of five element symmetrical circuit

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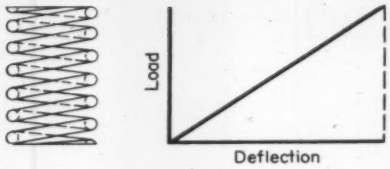
Helical Springs



$$E = \frac{1}{2} m v^2 \quad (1)$$

$$E = \frac{1}{2} k S^2 \quad (2)$$

$$E = \frac{1}{2} m v^2 + W S \quad (3)$$

EXAMPLE 1: Find spring rate. $S = 6$; $v = 30$; $W = 100$. Using Equation 1,

$$E = \frac{1}{2} \left(\frac{100}{g} \right) 30^2 = 1400 \text{ ft-lb}$$

and, solving Equation 2 for k,

LINEAR

WHATEVER has achieved a velocity must sooner or later be brought to a stop. Where possible, stopping is accomplished with a brake acting on a wheel or shaft. Where there is no wheel, as for a linear force, a shock absorber is used.

However, "shock absorber" as a general term is not quite accurate. With a well-designed stopping mechanism, only a slight amount of actual shock is produced. It is probably more correct to call such devices "energy absorbers," since absorbing energy is actually their function.

A linear energy absorber can be chosen from either of two groups. One group absorbs the energy of impact, retaining it until some manner of release is provided. The other group dissipates the energy of impact, either completely or to a major extent.

Factors to consider before selecting or designing a linear energy absorber are:

1. Weight, or mass, of the object to be stopped.
2. Velocity of the object at impact.
3. Maximum stress permissible in the object during the stopping period.
4. Stopping distance.
5. Available space for the energy absorber.
6. Allowable weight of the energy absorber.
7. Cost of the energy absorber.

Energy Dissipators

This group absorbs the energy of impact for later release. Various types of springs, including liquid springs and air cylinders, perform in this manner. These latter types are particularly useful for dash-

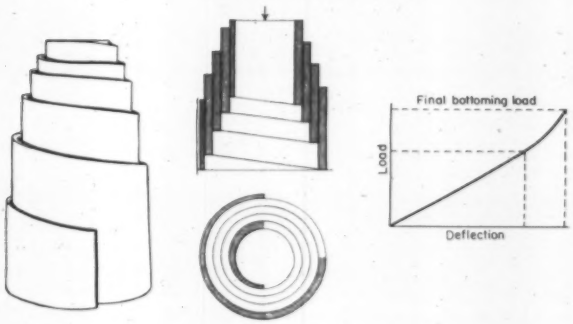
$$k = \frac{2E}{S^2} = 933 \text{ lb per in.}$$

EXAMPLE 2: Find spring rate, weight falling vertically. $S = 6$; $v = 30$; $W = 100$. Solving Equation 2 for k and combining with Equation 3,

$$k = \frac{mv^2}{S^2} + \frac{2W}{S} = \frac{\left(\frac{100}{g}\right) 30^2}{6^2} + \frac{2(100)}{6}$$

$$= 965 \text{ lb per in.}$$

Volute Springs



Nomenclature

A_p = Piston area, sq in.
A_o = Orifice area, sq in.
a = Acceleration of object, dv/dt, ft per sec^2
c = Orifice discharge coefficient
d = Piston diameter, in.
E = Energy, ft-lb
F = Force, lb
g = Acceleration of gravity, 32.2 ft per sec^2
k = Spring rate, lb per in. of deflection
m = Mass
n = Ratio of specific heat at constant pressure to specific heat at constant volume
P = Pressure, psi
p = Gas pressure, psi
p_1 = Initial gas pressure, psi
p_2 = Final gas pressure, psi
S = Spring deflection or piston travel, in.
S_1 = Internal length of cylinder, in.
V = Gas volume, cu ft
V_1 = Initial gas volume, cu ft
V_2 = Final gas volume, cu ft
v = Piston velocity, fps
v_f = Fluid velocity, fps
v_1 = Initial piston velocity, fps
v_2 = Final piston velocity, fps
W = Weight of object, lb
w = Specific weight of fluid, lb per cu ft

ENERGY ABSORBERS

10 ways to slow down or stop moving objects

pots where small momentary shocks are to be absorbed, or where energy of motion should be conserved for subsequent reversal of travel. Such types as rubber pads and heavy impact pendulums are not discussed, primarily because they are difficult to analyze accurately.

HELICAL SPRINGS

The simplest and most common energy absorber is the helical spring. It has a straight load-deflection curve. Energy to be absorbed by the spring is given in general form by Equation 1 and is also represented by the area under the curve, Equation 2.

In Example 1, the spring rate is determined. A spring can easily be designed for these conditions.[1]

[1]References are tabulated at end of article.

When the weight acting upon the spring is falling vertically, its effect must be accounted for by Equation 3. Solving again for k in Example 2 gives a higher spring rate.

In both cases the force acting on the object, and therefore the stress on the object, increases linearly with the deflection. Consequently, the maximum stress is twice the average stress. Energy stored in the spring can be used to return the object to its initial position or can be dissipated for some other purpose.

VOLUTE SPRINGS

When the energy to be absorbed is high and the space somewhat limited, a volute spring can be used more advantageously than the helical spring.

The volute spring has a nonlinear load-deflection characteristic and is considerably more complex in design.[2]

The area under the curve again equals the energy absorbed by the spring. For this case, the maximum load is more than twice the average load, and the maximum stress of the object being stopped will be greater than it would be for helical springs.

LEAF SPRINGS

Usually associated with automobiles, multiple-leaf springs find limited use in other applications as energy absorbers. They are inherently self-damping because of friction between adjacent leaves. Design analysis is somewhat complex and will not be attempted here. Single-leaf, or cantilever, springs can be analyzed in a manner similar to that used for helical springs.[1]

CONICAL-DISC SPRINGS

The Belleville or conical-disc spring can also absorb more energy in a given space than the helical spring. These springs are most applicable for a large load and small deflection. When arranged in stacks, they may be purchased as assemblies. They possess inherent damping characteristics similar to leaf springs, and oscillations soon die out after impact.

Load-deflection curves depend upon spring design and may vary from an almost straight line to a very definite curve. This permits a better ratio of maximum stress to average stress than can be obtained for the previously mentioned springs.[3]

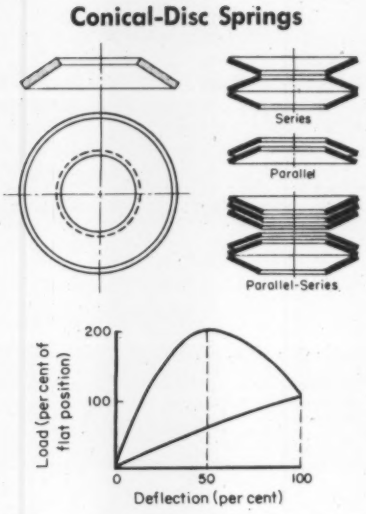
LIQUID SPRINGS

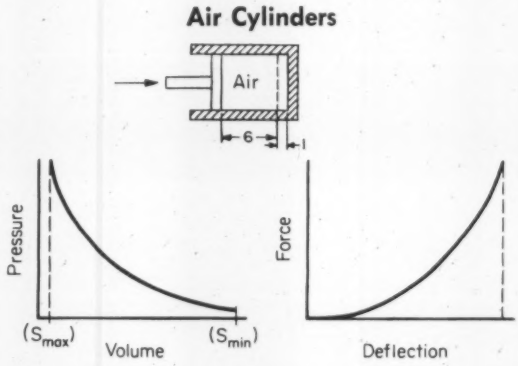
Special oils or fluids are used to make liquid springs that can exert as much as ten times the force of helical springs for the same amount of space. These springs are used to cushion recoil of aircraft cannon and impact on aircraft landing gear. Because of difficulties in sealing the liquid against extremely high pressures, they are ordinarily purchased rather than designed to fit a specific case.

AIR CYLINDERS

Rapid compression of air can be considered to be adiabatic. The pressure-volume relationship is shown by the exponential curve and by Equations 4 and 5. By use of Equations 6 and 7, the curve of force-deflection is obtained as the reverse of the pressure-volume curve.

As before, the area under the force-deflection curve represents the energy absorbed by the air. Area under the pressure-volume curve also equals





$$pV^n = \text{Constant} \tag{4}$$

$$p_1V_1^n = p_2V_2^n \tag{5}$$

$$F = PA_p \tag{6}$$

$$SA_p = V_1 - V_2 \tag{7}$$

$$E = \int p\,dV \tag{8}$$

$$E = \frac{p_2V_2 - p_1V_1}{1 - n} \tag{9}$$

EXAMPLE: Find diameter of piston. $E = 1400$; $n = 1.4$; $p_1 = 14.7$; $S = 6$; $v = 30$; $W = 100$; $V_2 = V_1/(6 + 1) = V_1/7$. Rearranging Equation 5,

$$\frac{p_2}{p_1} = \frac{V_1^n}{V_2^n} = 7^{1.4} = 15.6$$

Substituting in Equation 9 and rearranging,

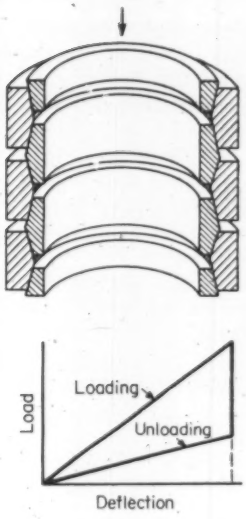
$$E = \frac{p_1\left(\frac{p_2}{p_1}\frac{V_1}{7} - V_1\right)}{1 - n}$$

$$V_1 = \frac{1400(1 - 1.4)}{14.7\left(\frac{15.6}{7} - 1\right)} \times 12 = 372 \text{ cu in.}$$

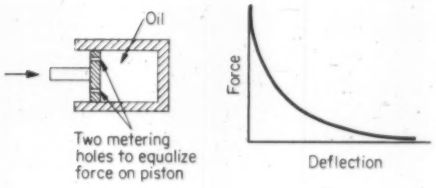
Then,

$$d = \left(\frac{4V_1}{\pi S_1}\right)^{1/2} = \left[\frac{4(372)}{3.14(7)}\right]^{1/2} = 8.22 \text{ in.}$$

Ring Springs



Variable-Pressure Shock Absorbers



$$E = \int_0^{S(max)} F\,dS \tag{10}$$

$$E = \frac{1}{2} m(v_1^2 - v_2^2) \tag{11}$$

$$\ln \frac{v_1}{v_2} = \frac{w A_p^3 S}{3456 c^2 A_o^2 W} \tag{12}$$

$$F_{max} = P_{max} A_p \tag{13}$$

$$P_{max} = \frac{w A_p^2 v_1^2}{288 g c^2 A_o^2} \tag{14}$$

EXAMPLE 1: Find orifice area and maximum pressure. $A_p = 1$; $c = 0.7$; $S = 12$; $v_1 = 20$; $v_2 = 0.05\ v_1$; $W = 1000$; $w = 50$. Using Equation 12,

$$\ln \frac{20}{0.05(20)} = \frac{50(1)^3(12)}{3456(0.7)^2 A_o^2 (1000)}$$

$$A_o = 0.0109 \text{ sq in.}$$

From Equation 14,

$$P_{max} = \frac{50(1)^2(20)^2}{288(32.2)(0.7)^2(0.0109)^2} = 37{,}100 \text{ psi}$$

the energy absorbed, as given by Equation 8. For the adiabatic process, Equation 9 is obtained.

In the example, the energy absorbed is the same as for the helical spring problem. To provide a safety margin of 1 in. overtravel, a total possible stroke of 7 in. is used. Starting with atmospheric pressure in the cylinder, the initial volume is calculated, which is then used to find the piston diameter.

This method is approximate and must be checked by experiment since piston friction has been ignored. Assuming the compression is adiabatic also introduces some error because the compression would actually be polytropic. However, the calculations give a good approximation to the problem.

Another point of interest as noted from the pressure-volume curve is that maximum pressure, and therefore maximum stress, is considerably greater than the average pressure. Also, energy of impact remains stored in the cylinder and must be considered in the design. A bleed orifice can easily be placed in the end of the cylinder to dissipate this energy, but the calculations are considerably more complex and lengthy. However, the problem can be attacked through step integration.

Energy Storers

These energy absorbers might almost be termed "linear brakes," because they stop motion and dissipate energy. Ring springs, hydraulic shock absorbers, and different types of "single-shot" shock absorbers fall into this category.

RING SPRINGS

Although somewhat of a borderline case, ring springs are placed in this group because they do dissipate absorbed energy as friction between their sections in a few cycles. This type of spring has a high load capacity for its size and weight and will absorb linear energy with little recoil. Having a linear load-deflection characteristic like the helical spring, the ring spring exerts a maximum stress in the object being stopped equal to twice the average stress.

Springs of this type have been used for loads of 2 to 100 tons and with deflections between 1 in. and 1 ft. However, there is no reason why they can not be used for smaller loads. Analysis is relatively involved and full coverage is not warranted here.[4]

VARIABLE-PRESSURE SHOCK ABSORBERS

A popular device for absorbing linear energy is the hydraulic shock absorber. The most common type has a constant-area metering orifice which causes pressure in the cylinder, and therefore force

acting to stop the object, to be proportional to the square of the velocity of the object as indicated by the force-deflection curve.

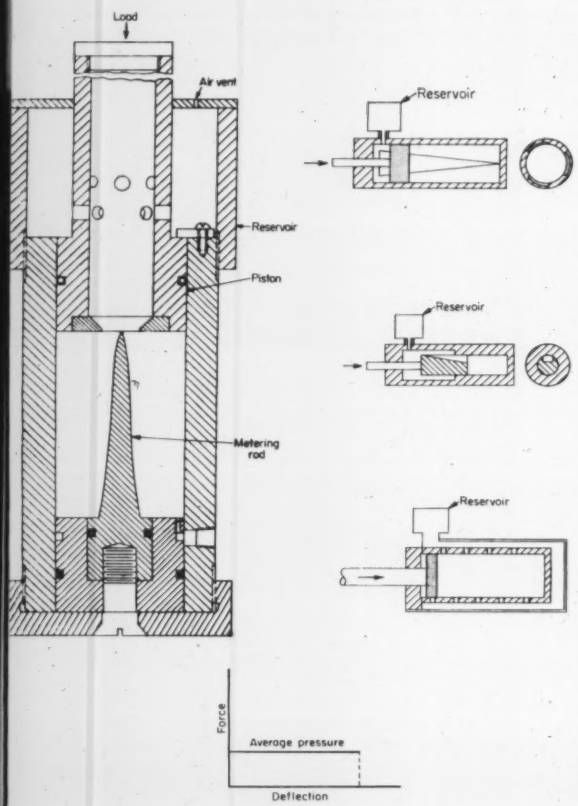
Energy absorbed is given by Equation 10, and the energy given up by the object being stopped is given by Equation 11. Setting these two relationships equal to one another results in Equation 12. This expression implies theoretically that the final velocity can never be brought to zero because the value of the natural logarithm would then become infinite. However, for purposes of calculation, the velocity can be reduced to a very small value which is the same as stopping the moving object.

Maximum pressure occurs at the beginning of the stroke, where the initial and final velocities are equal, and can be determined through Equations 13 and 14.

In the example, a velocity decay of 95 per cent is considered equivalent to stopping the object. Solving first for orifice area permits determination of maximum pressure, which is found to be quite high. It should be noted that friction in the packing gland and between piston and cylinder has been neglected. Also, the 95 per cent velocity decay is a conservative estimate.

As noted previously, the constant-area orifice shock absorber can only slow the falling object to the point where the resisting force is equal to the weight or force exerted by the object. Depending upon the amount of this weight, a severe shock could be produced at the end of the stroke.

Constant-Pressure Shock Absorbers



$$\int_0^{S(max)} F dS = \frac{1}{2} m(v_1^2 - v_2^2) \qquad (15)$$

$$F = \frac{w A_p^3 v_1^2}{288 g c^2 A_o^2} \qquad (16)$$

$$v_f = \frac{v A_p}{A_o} \qquad (17)$$

$$A_o = \left[\frac{w A_p^3 (v_1^2 - 2aS)}{288 c^2 W a} \right]^{1/2} \qquad (18)$$

$$A_o = \left[\frac{w A_p^3 (v_1^2 - 2aS)}{288 c^2 W} \frac{1}{g + a} \right]^{1/2} \qquad (19)$$

$$a = \frac{v_1^2}{2S_{max}} \qquad (20)$$

CONSTANT-PRESSURE SHOCK ABSORBERS

Hydraulic linear energy absorbers can be built so that cylinder pressure is constant, and very nearly equal to the calculated average pressure. These devices, which have been used in cannon recoil systems for many years, permit a considerably reduced stress in the object being stopped with resultant weight and space savings in the stopping mechanism. Such a shock absorber has a varying fluid-discharge area which is carefully calculated to give constant cylinder pressure, and consequently, constant resisting force.

To compare the variable-pressure shock absorber with the constant-pressure type, the average pressure can be found from $P_{ave} AS = (mv^2)/2$. For the values given in the *Variable-Pressure Shock Absorbers* example, average pressure is found to be 6210 psi, compared with a maximum pressure of 37,100 psi. In a constant-pressure absorber, this lower pressure could stop the same load in the same distance.

In effect, with this constant-pressure shock absorber, about 1/6 the pressure is used for equivalent "stopping power." Obviously, system stresses are less, and sealing is much easier. This ideal case is represented in the force-deflection diagram.

The relationship of discharge area versus piston travel is found from Equation 15, which combines Equations 10 and 11. Equation 16 is obtained from Equation 14. Fluid velocity is found by a ratio, Equation 17. Differentiating both sides of Equation 15 with respect to time, dividing by dS, combining terms, and substituting the basic definition of a into the result gives Equation 18. This equation determines the orifice area for any point in the stroke of the shock absorber.

For a vertically falling object, additional energy, equal to weight times distance, must be absorbed and

dissipated. This modification is shown in Equation 19. The acceleration is a constant and can be determined by Equation 20.

"SINGLE-SHOT" SHOCK ABSORBERS

Similar to the constant-area orifice shock absorber is the plastic extrusion type in which a viscous plastic substance is extruded from a constant-area orifice or nozzle. This is essentially a "single-shot" operation since the plastic must be replaced before the system can operate again. Such units have been proposed for use on the front bumpers of automobiles to reduce shock of impact in an accident.

With this system, rate of energy absorption is proportional to the rate of extrusion, and maximum resistance will be exerted at the beginning of the stroke where the velocity is greatest. The force will then decay exponentially, as shown for the constant-area orifice hydraulic shock absorber.

Another type of shock absorber, somewhat similar to the plastic extrusion type, depends upon crushing a material to absorb the energy of impact. Corrugated paper rolled up and struck in a direction parallel to the axis of the corrugations is an example.

Special honeycomb materials have been produced to provide energy-absorption media. Some of these provide an essentially constant resisting force as they deform. This type of material has been used rather extensively in packing and has also been proposed for use on automobile bumpers.

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3. E. T. Fortini—"Conical-Disc Springs," MACHINE DESIGN, Vol. 30, No. 18, Sept. 4, 1958, p. 139.
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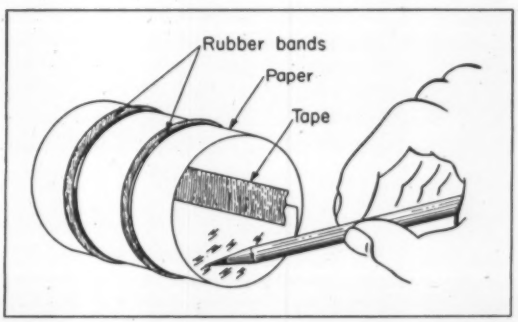
Tips and Techniques

Pencil Pointer

To prevent smudging of drawings, roll a sheet of paper or sandpaper and tape ends to form a tube makes a useful pencil pointer. Rubber bands



around the outside prevent sliding, while the tube retains the graphite particles and reduces smudging. —CHARLES H. SEKERA, *Westinghouse Research Laboratories, Pittsburgh, Pa.*

Cube Roots

A desk calculator can be used effectively to find the cube root of a number from the following formula:

$$\sqrt[3]{n} = R_t \left[0.5 + \sqrt{\frac{1}{3}\left(\frac{n}{R_t^3}\right) - \frac{1}{12}} \right]$$

where n = number for which the cube root is to be found and R_t = a trial root. For example, to find the cube root of 115, select a trial root of 4.5. Then,

$$\sqrt[3]{115} = 4.5 \left[0.5 + \sqrt{\frac{1}{3}\left(\frac{115}{4.5^3}\right) - \frac{1}{12}} \right]$$

$$= 4.5[0.5 + \sqrt{0.420667 - 0.083333}\,]$$

$$= 4.5[0.5 + 0.580805]$$

$$\sqrt[3]{115} = 4.863623$$

By comparison, the exact cube root is 4.862994. If closer results are desired, the procedure can be repeated using 4.862 as a trial root.—RICHARD M. EVANS, *ITT Laboratories, Fort Wayne, Ind.*

Squaring Numbers

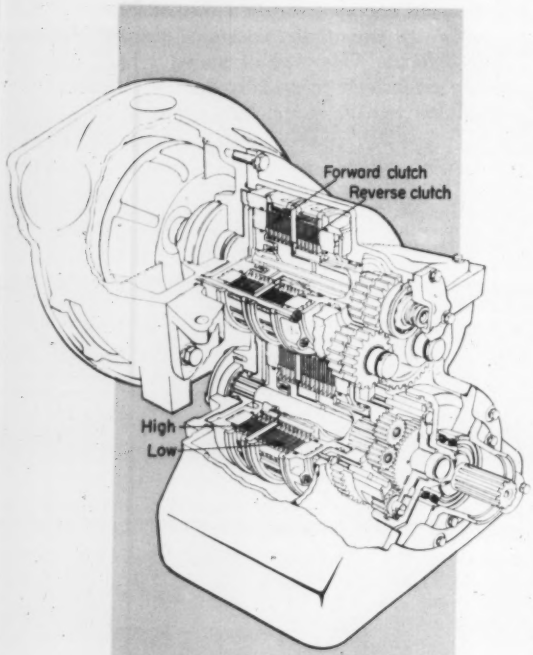
A simplified method for finding the exact square of a number that is less than 1000 makes use of the expansion, $(a + b + c)^2 = a^2 + b^2 + c^3 + 2ab + 2bc + 2ac$.

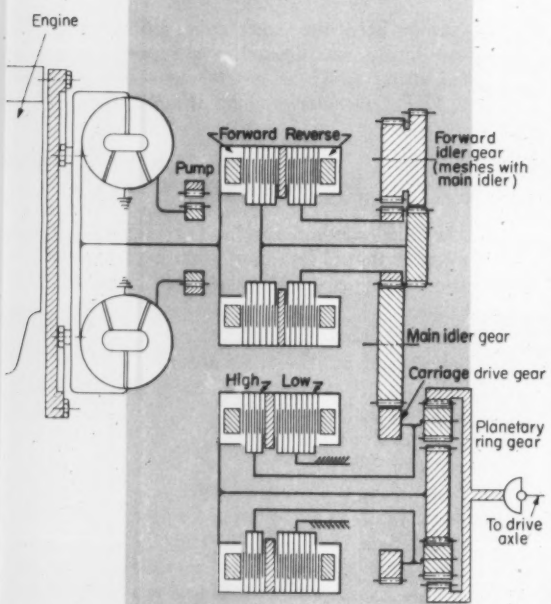
To find the square of 689:

Combine and put down squares of 6, 8, 9:	366481
Product of 2(6)(8):	96
Product of 2(6)(9):	108
Product of 2(8)(9):	144
Add to obtain exact square:	474721

The last digit of the first product is placed under the third digit of the expanded number, the last digit of the second product is placed under the fourth digit of the expanded number, and the last digit of the last product is placed under the fifth digit of the expanded number.—HURSH PARIKH, *Hengelo, Holland.*

Dual-Range Transmission Permits





FORWARD-REVERSE SHIFTING without declutching or synchronizing gears is easily done with the new dual-range, power-shift Hystamatic transmission. As reported by design engineer Richard Aaron, the transmission was developed by the Hyster Co. for their Challenger line of lift trucks.

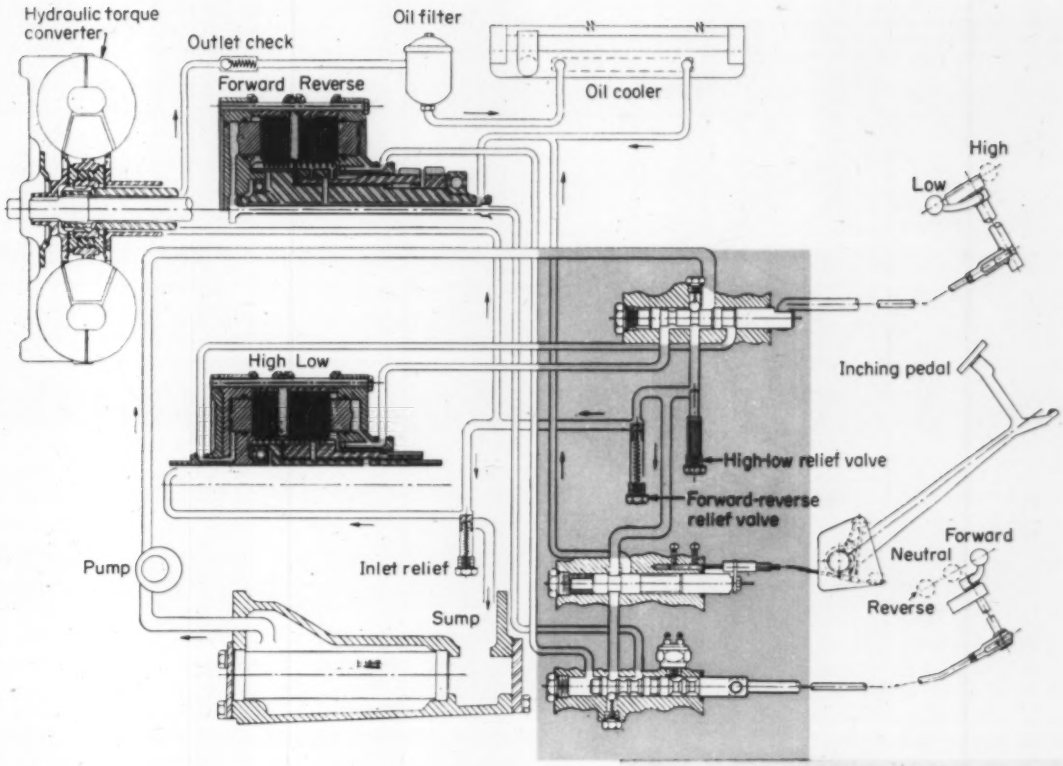
Mounted directly to the engine adapter plate, the new power-transmission unit receives input power from the engine flywheel through a flexible drive plate. Output of the single-stage industrial converter goes to the input member of the forward-reverse directional element.

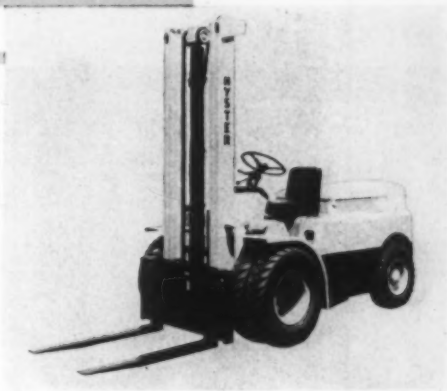
FORWARD-REVERSE DIRECTIONAL ELEMENT consists of two oil-pressure-actuated multiple-disc clutches. The input member envelopes the pack and carries the pistons and splines which drive the steel separator discs of both clutches. Forward and reverse output shafts are concentrically arranged and carry the friction discs. Engagement of one or the other clutch imparts either forward or reverse rotation of the main idler gear which, in turn, drives the carriage drive gear of the compound planet-gear unit.

A similar double-clutch pack mounted directly below the reversing pack controls the planet assembly. The sun-gear reaction shaft is splined to the outer envelope of the range unit. The high-speed clutch output is splined to the planet carriage, and engagement of this clutch locks the sun to the carriage, producing a 1 to 1 ratio.

The low-speed clutch output is grounded to a case component, and its engagement holds the sun stationary, providing the reaction element about which the planet pinions rotate. The output ring gear is thus caused to rotate at a lesser speed, but at a higher torque level. Both high and low planet ratios are supplemented by the spur-gear reduction between the forward-reverse pinions and the carriage drive gear.

"On-the-Fly" Power Shifting



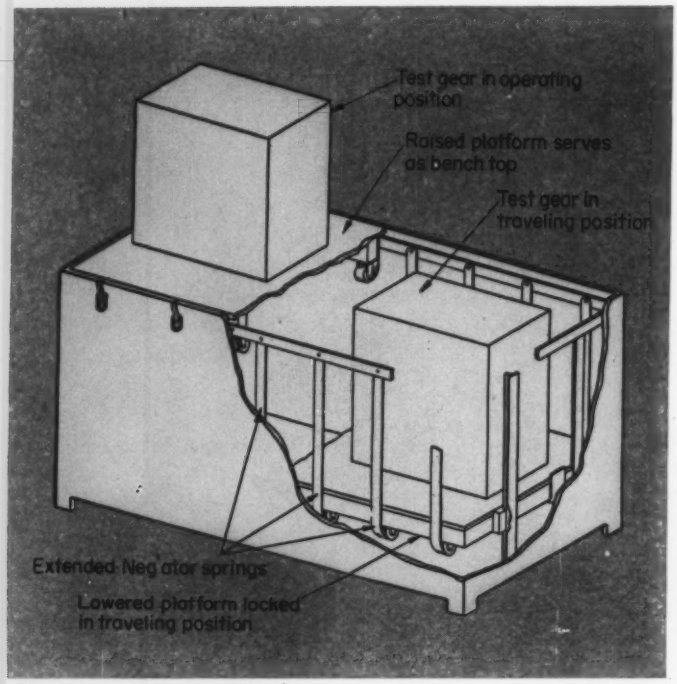


HYDRAULIC CONTROL SYSTEM is composed of a pump driven by the impeller hub of the torque converter and a valve containing a range spool, a directional spool, an operator-controlled variable-pressure spool, and all necessary converter and transmission pressure regulators. In addition, a sump screen, heat exchanger, and filter are provided. The valve mounts to the side of the transmission case.

Left-foot control of the variable-pressure regulator lowers directional clutch piston pressure in proportion to pedal stroke. Oil dumped from this regulator is directed to the center of the directional clutch pack where it is thrown radially through the clutch discs for cooling. Oil cooling prevents excessive rise in clutch temperature. The variable regulator gives operator control over clutch capacity and permits precise inching of fork truck.

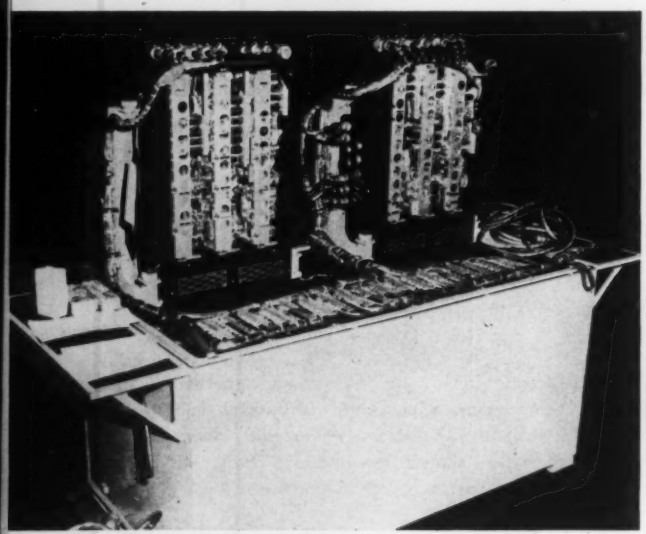
Designed-in ruggedness of power train permits direction-of-travel change by a hand-operated selector lever which mechanically operates the directional spool in the transmission valve. No declutching is necessary. At moderate speeds the operation is smooth and safe. For extremely unstable loads and at higher speeds, the operator can at his discretion control clutch engagement with the left foot pedal.

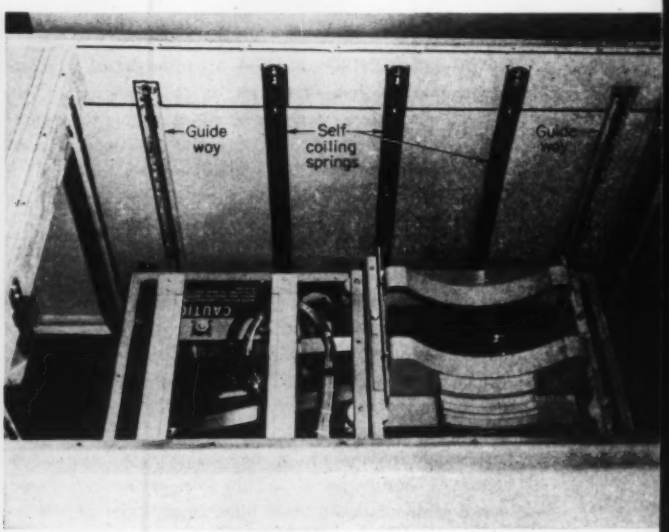
Flat Springs Double as Elevator Cables and "Motors"

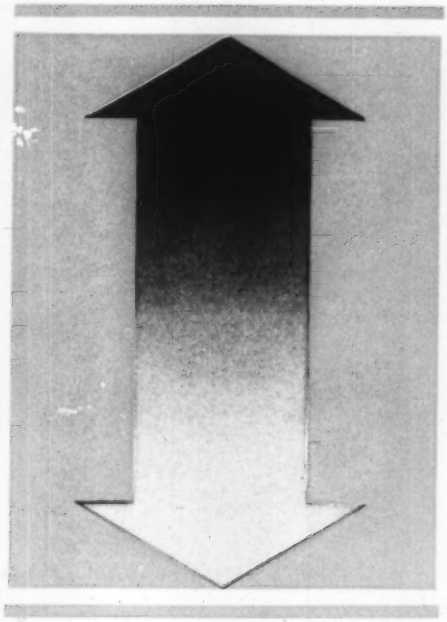

Test gear in operating position
Raised platform serves as bench top
Test gear in traveling position
Extended Neg'ator springs
Lowered platform locked in traveling position

CONSTANT-FORCE LIFTING ACTION is produced in a lightweight elevating system by special-design, self-coiling springs. Manufactured by Hunter Spring Co., each spring exerts a constant 25-lb lifting force throughout a vertical travel distance of 23 in. Each spring is made of stainless steel 0.025 in. thick and 1.5 in. wide.

This multiple-spring counterbalance system is applied in electronic ground-support equipment designed by Arma Div., American Bosch Arma Corp. for the B-52. The electronic test-and-maintenance equipment is mounted on an elevator-like platform which serves as a workbench in the up position. The box-like base, made of bonded aluminum-plywood construction, doubles as a shipping container for the electronic test equipment. To "package" the equipment for moving to a new location, the operator need only push it down and close the lid on the box.







THERMAL STRESSES IN DESIGN

Part 9— Elastic-Stress Solutions

- *Reciprocal Theorem*
- *Finite Differences*

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SOLUTION of thermal-stress problems by exact methods is often difficult. However, there are available to the designer certain approximate methods which simplify solution. The first method outlined in this article is a continuation of the description of energy methods and makes use of Betti's reciprocal theorem. Although not strictly an energy method, in that the stored energy in the body is not considered, this method uses the concept of work as the product of a force exerted through a distance. Also discussed in this article is an approximate method of solving the thermoelastic equations by means of finite differences.

▶ Reciprocal Theorem

The reciprocal theorem provides a relationship between the displacements and forces of two independent external loading systems. If the displacements throughout the body due to each force system are determined, then the work done by the forces of the first system on the corresponding displacements of the second system is equal to the work done by the forces of the second system on the displacements of the first. The work done is hypothetical since the forces of one system are multiplied by the displacements of the other system. Nevertheless, the theorem provides a useful relation. One of the selected force systems is usually simple, and the displacements can be determined by inspection or from a prior analysis. The theorem provides a relation among the forces and displacements of the second set.

Nomenclature

A	= Cross-sectional area
a, b, c, d	= Arbitrary constants
E	= Elastic modulus
h	= Thickness
I	= Moment of inertia
L	= Length
n	= Distance normal to boundary surface
p, q, r, s	= Boundary points
r	= Radius or radial
S	= Surface
T	= Temperature
t	= Tangential
u, v, w	= Displacements
V	= Volume
X, Y, Z	= Body forces
X_s, Y_s, Z_s	= Surface forces
α	= Coefficient of expansion
δ	= Deflection
ϵ	= Strain
μ	= Poisson's ratio
ρ	= Density of material
σ	= Stress
ϕ	= Stress function
ω	= Rotation
del^2	= Laplacian operator
del^4	= Operator
$\int_p$	= Line integral

Working Equations: A thermal-stress system is regarded as an equivalent set of body and surface forces, and then the theorem is applied by considering the thermal-stress force system in conjunction with a simple force system.

Usefulness of the result depends on the choice of the second system. Several results of design value as well as academic interest have been derived.[9]

Application of the reciprocal theorem, together with the divergence theorem gives[10] (see Nomenclature)

$$\int (X'u + Y'v + Z'w)dV + \int (X_s'u + Y_s'v + Z_s'w)dS = \frac{E}{1-2\mu}\int \left(\frac{\partial u'}{\partial x} + \frac{\partial v'}{\partial y} + \frac{\partial w'}{\partial z}\right)\alpha T dV \qquad (47)$$

In general, the auxiliary stress system is usually simple, and the first of the integrals which involves body forces of the system is usually absent.

If the auxiliary stress system is assumed to be hydrostatic pressure, a computable elongation system which can be substituted into Equation 47 is produced. Simplification results in an expression for the change in volume of a solid body.

$$\Delta V = \int 3\alpha T dV$$

The change in volume of the body is due solely to thermal dilation. Thus, thermal stresses have no effect on the body volume change. This is qualitatively possible because the thermal-stress system is internally balanced.

If the body is hollow, change in volume of the cavity is obtained by selecting a uniform normal pressure on the internal cavity as the auxiliary force system. Hence, the change in volume depends on the shape of the body and the cavity. For simple shapes, the auxiliary displacements are readily determined and substituted into Equation 47.

Four useful design formulas, which relate to deformations of bars subjected to nonuniform temperature distribution, have been derived.[9] Since the bar is essentially three-dimensional, the quantities are average values at the locations considered.

AVERAGE EXTENSION: The auxiliary stress system for a bar of uniform section is taken as simple tensile stress along the axis of the bar, and the mean thermoelastic extension is

$$\Delta L = \frac{1}{A}\int \alpha T dV$$

CHANGE IN ANGLE: The auxiliary system for the bar in flexural rotation is pure bending moment, and the rotation is

$$\theta_y = \frac{1}{I_y}\int \alpha T x dV$$

DEFLECTION: The auxiliary force system for an end of a cantilever relative to the fixed end is taken as a force on the free end in the direction of the desired deflection, and the mean deflection is

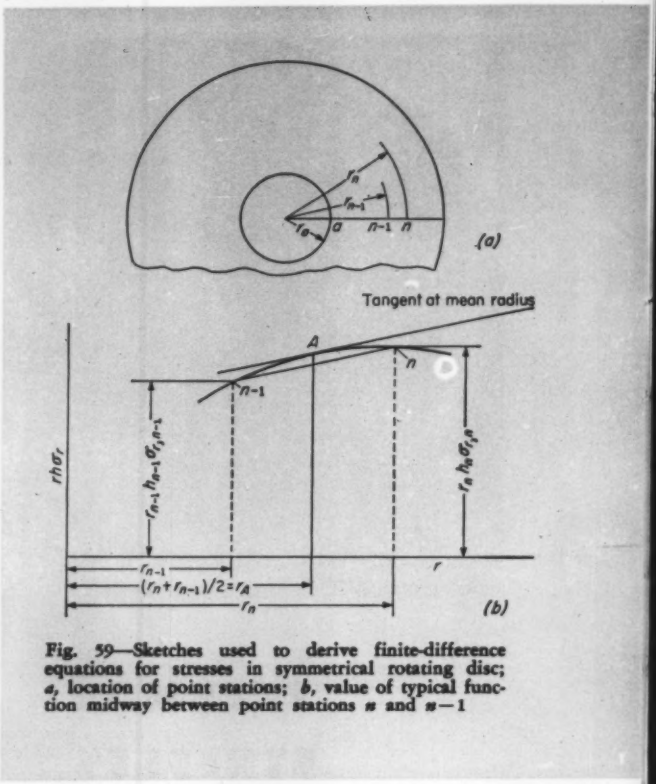

Fig. 59—Sketches used to derive finite-difference equations for stresses in symmetrical rotating disc; *a*, location of point stations; *b*, value of typical function midway between point stations *n* and *n*−1

$$\delta_y = -\frac{1}{I_y}\int \alpha T y(l-z)dV$$

where y = distance from fixed end, and z = distance from the centroid in the direction of deflection.

TORSIONAL ROTATION: The auxiliary force system for a bar with one end rotated relative to the other is essentially a twisting couple on the ends, and the mean torsional rotation in the thermal stress system is zero.

Similar expressions can be obtained for these equations in the x direction.

Finite Differences

If differential equations of equilibrium and compatibility are solvable, then the solution constitutes an exact point-to-point variation of these quantities. However, if exact solution is not possible, the finite-difference method can be used. Here, the differential equations are replaced by a series of difference equations, which relate stresses, strains, or stress-functions at stations removed from each other by finite dimensions. These equations lead to solutions that are adequate for most design purposes.

Equation solution usually proceeds by successive calculations in which values of the desired functions are determined from the known values of the function at adjacent stations. Usually, the process is applicable only to numerical problems, although literal solutions can be obtained if cumbersome final formulas are tolerated.

[9]References are tabulated at end of article.

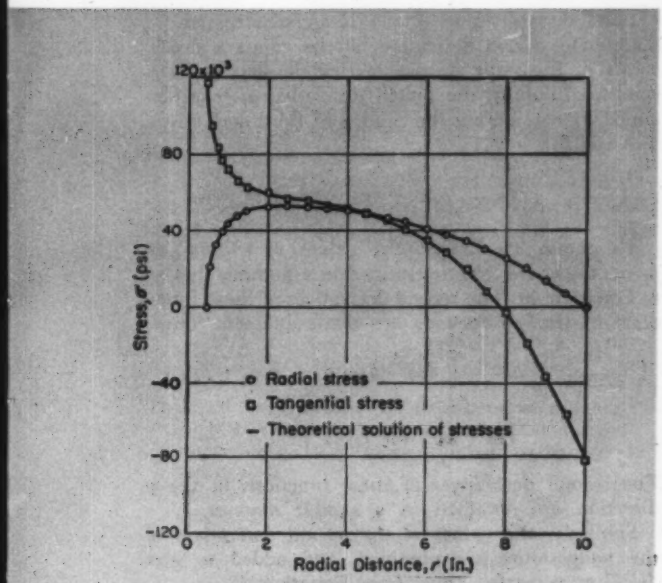

Fig. 60—Comparison between theoretical and finite-difference solution stresses in parallel-sided disc of 20-in. diameter; speed = 10,000 rpm, temperature gradient = 600 deg F at center to 1200 deg F at rim, $E = 30 \times 10^6$ psi, $\alpha = 8 \times 10^{-6}$ in./(in. deg F), $\mu = 0.3$

Two approaches can be followed to obtain the difference equations:

1. By reference to the physical problem in a manner similar to differential equation derivation, but by considering only points finitely removed from each other.
2. By conversion of differential equations into difference equations. Use is made of the basic definitions of ordinary and partial derivatives.

The latter approach is usually easier, since it permits the use of final equations which are derivable only after considerable manipulation of basic equations.

Application of Differential Equations: Finite differences are sometimes useful in the solution of ordinary differential equations, particularly when the coefficients are complicated functions of the independent variable. If a disc thickness varies with radius, and if the material properties vary appreciably with temperature, the differential equations have variable coefficients which make closed-form solution impractical.

If finite differences are used, the region of interest is divided by a number of discrete point stations. The differential equation is converted to difference equations which relate the conditions at one station to those at the adjacent stations. Thus, if the stresses at one station are known, the stresses at other stations can be computed. If stresses at one station are not completely known, stresses at all stations are expressed in terms of the unknown stresses at the reference station. Unknown stresses are determined later from given boundary conditions.

The rotating disc is used as an example of the first formulation method.[11] The compatibility equation is converted to a stress equation by use of the stress-strain relation and the equilibrium equation, Equation 22,[6] which determine the radial and tangential stresses at each radius. The converted compatibility equation is Equation 24,[6] where ω is the angular velocity and T is the temperature increment above which there is zero thermal stress.

In conversion of differential equations to finite differences, a number of point stations along the disc radius, Fig. 59*a*, are chosen. If the stress distribution in the disc has been determined, all quantities are known at each of the point stations, and the values of corresponding quantities at the point A, midway between the n and $(n-1)$ point stations can be approximately determined. In the plot of $rh\sigma_r$ against r, Fig. 59*b*, the radius at point A is

$$r_A = \frac{1}{2}(r_{n-1} + r_n)$$

and the value $rh\sigma_r$ is

$$(rh\sigma_r)_A \approx \frac{1}{2}(r_{n-1}\, h_{n-1}\, \sigma_{r,n-1} + r_n h_n \sigma_{r,n})$$

The slope of the curve at point A, which approximates the slope of the chord joining points n and $n-1$, is

$$\frac{d}{dr}(rh\sigma_r)_A \approx \frac{r_n h_n \sigma_{r,n} - r_{n-1} h_{n-1} \sigma_{r,n-1}}{r_n - r_{n-1}}$$

In a similar way, the values of each of the other variables entering into the equations can be evaluated for point A. Substitution of these quantities into equations 22 and 24 leads to two finite difference equations and the solution is obtained by successively expressing the stresses at all stations in terms of the stresses at the first station. For a solid disc, the first station is taken at a very small radius, and for a disc with a central hole, the first station is taken at the radius of this hole. In either case only one unknown stress is involved at the first station. Thus all the stresses in the disc can progressively be expressed in terms of this single unknown stress, the magnitude of which is determined from an expression for another known boundary condition. Once this stress is known, all others become known through the finite difference solutions.[11]

Validity of the finite difference method for computing stresses is shown in a comparison, Fig. 60, of the stresses in a parallel-sided disc, computed by exact theory and by finite differences. The agreement is seen to be good. Of course, the principal value of the method lies in manipulation of equations that cannot readily be solved by exact methods.[11] The rapidity of solution can also be increased if the point stations are judiciously selected according to a pre-established pattern.[12]

Two-Dimensional Problems: The finite difference method has special application in two-dimensional boundary problems, especially when geometric boundaries are irregular. Since the most general two-dimensional problem relates to the solution of

the biharmonic equation, this application will be described.

Thermal stresses are determinable, once the stress function has been obtained, from Equation 27,[6] or

$$\frac{\partial^4\phi}{\partial x^4} + \frac{2\partial^4\phi}{\partial x^2\partial y^2} + \frac{\partial^4\phi}{\partial y^4} + E\alpha\left[\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right] = 0 \quad (48)$$

Equation 48 must be rewritten in finite-difference form with reference to the basic definitions of partial derivatives. Imagine a body, Fig. 61, divided by a rectangular grid, and consider the values of the stress function ϕ at the nodal points such as ϕ_0, ϕ_1, and ϕ_2. To obtain the higher derivatives, the lower derivatives are determined first. Thus midway between points 0 and 1,

$$\left(\frac{\partial\phi}{\partial x}\right)_A \approx \frac{1}{\delta}(\phi_1 - \phi_0)$$

Midway between points 0 and 3,

$$\left(\frac{\partial\phi}{\partial x}\right)_B \approx \frac{1}{\delta}(\phi_0 - \phi_3)$$

The second derivative at point 0 is determined from the change of slope between A and B.

$$\left(\frac{\partial^2\phi}{\partial x^2}\right)_0 = \frac{1}{\delta}\left[\left(\frac{\partial\phi}{\partial x}\right)_A - \left(\frac{\partial\phi}{\partial x}\right)_B\right]$$

$$= \frac{1}{\delta^2}(\phi_1 - 2\phi_0 + \phi_3) \quad (49)$$

Similarly, expressions for the second derivative at points 1 and 3 can be written in terms of the values of the stress functions at 0-1-5 and 0-3-9, respectively.

Third derivatives at A and B are determined by changes in second derivatives at the adjacent nodal points in the same ways that first derivatives were obtained. Finally the fourth derivative at 0 is obtained by considering the change in third derivatives at A and B.

$$\left(\frac{\partial^4\phi}{\partial x^4}\right)_0 = \frac{1}{\delta^4}(6\phi_0 - 4\phi_1 - 4\phi_3 + \phi_5 + \phi_9)$$

To obtain $\partial^4\phi/\partial x^2\partial y^2$, the values of $\partial^2\phi/\partial x^2$ at points 0-2-4 are first determined in a manner similar to Equation 49. The second derivatives of these functions in the y-directions are then obtained. Thus,

$$\left(\frac{\partial^4}{\partial x^2\partial y^2}\right)_0 \approx \frac{1}{\delta^4}\left[4\phi_0 - 2(\phi_1 + \phi_2 + \phi_3 + \phi_4) + \phi_6 + \phi_8 + \phi_{10} + \phi_{12}\right]$$

The second derivatives of these functions in the y direction are obtained in a similar manner.

Similarly, the values of the second derivatives of the temperature are obtained, and added to give del^2T at point 0. Thus, from Equation 48,

$$20\phi_0 - 8(\phi_1 + \phi_2 + \phi_3 + \phi_4) + 2(\phi_6 + \phi_8 + \phi_{10} + \phi_{12}) + (\phi_5 + \phi_7 + \phi_9 + \phi_{11}) + E\alpha(T_1 + T_2 + T_3 + T_4 - 4T_0) = 0 \quad (50)$$

BOUNDARY CONDITIONS: For a singly-connected region, there is only one boundary. Values of ϕ at and near the surface are taken as zero, so that $\phi = \partial\phi/\partial x = \partial\phi/\partial y = 0$. Thus Equation 48 is solved for this set of boundary conditions only.

For a multiply-connected region, the boundary

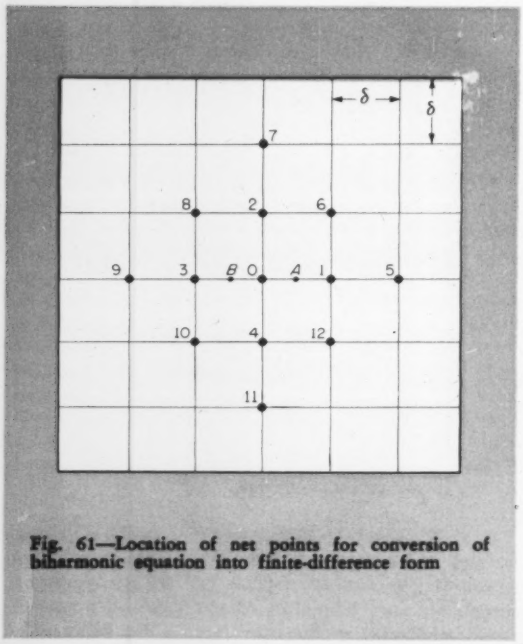

Fig. 61—Location of net points for conversion of biharmonic equation into finite-difference form

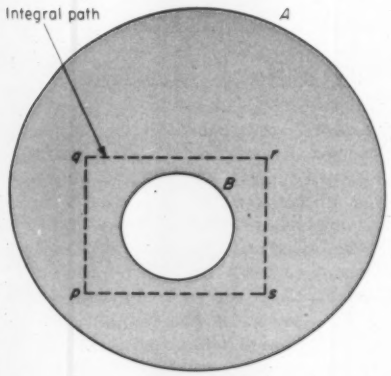

Fig. 62 — Boundary conditions for doubly-connected region

conditions become much more complicated. Consider a plate with an outer surface A and hole B, Fig. 62. At B, the boundary conditions are $\phi = ax + by + c$, $\partial\phi/\partial x = a$, and $\partial\phi/\partial y = b$. However, a, b, and c cannot be arbitrarily chosen as zero, since this choice was used in setting $\phi = \partial\phi/\partial x = \partial\phi/\partial y = 0$ at A. The determination of these constants is discussed later. For the present, the problem is limited to the solution which contains the three adjustable constants a, b, and c. Consider a set of particular solutions:

1. Function ϕ_a satisfies the differential equation $\text{del}^4 \phi_a = 0$ with $\phi_a = \partial\phi_a/\partial x = \partial\phi_a/\partial y = 0$ at boundary A, and $\phi_a = x$, $\partial\phi_a/\partial x = 1$, and $\partial\phi_a/\partial y = 0$ at boundary B.
2. Function ϕ_b satisfies the differential equation $\text{del}^4 \phi_b = 0$ with $\phi_b = \partial\phi_b/\partial x = \partial\phi_b/\partial y = 0$ at boundary A, and $\phi_b = y$, $\partial\phi_b/\partial x = 0$, and $\partial\phi_b/\partial y = 1$ at boundary B.
3. Function ϕ_c satisfies the differential equation $\text{del}^4\phi_c = 0$ with $\phi_c = \partial\phi_c/\partial x = \partial\phi_c/\partial y = 0$ at boundary A, and $\phi_c = 1$ and $\partial\phi_c/\partial x = \partial\phi_c/\partial y = 0$ at boundary B.
4. Function ϕ_d satisfies the differential equation $\text{del}^4\phi_d + Ea\,\text{del}^2 T = 0$ with $\phi_d = \partial\phi_d/\partial x = \partial\phi_d/\partial y = 0$ at boundaries A and B.

Each of these four solutions constitutes a problem with specific numerical boundary conditions, and once they have been obtained,

$$\phi = a\phi_a + b\phi_b + c\phi_c + \phi_d \qquad (51)$$

By direct substitution, the compounded solution, Equation 51, is a final solution, since it satisfies the differential equation, Equation 48, and the boundary conditions $\phi = \partial\phi/\partial x = \partial\phi/\partial y = 0$ at A, $\phi = ax + by + c$, $\partial\phi/\partial x = a$ and $\partial\phi/\partial y = b$ at B.

Boundary Values: Each of the foregoing particular solutions has specific numerical values for the stress function and its derivatives on the boundary. However, since finite-difference equations considered have values of ϕ at specific nodal points only, and since nodal points are not at the boundaries in irregular shapes, the values at the nodal points in the vicinity of the boundary must be determined.

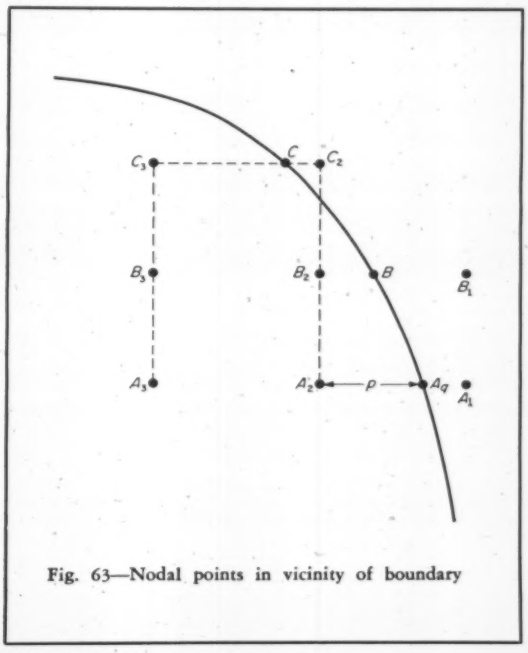

Fig. 63—Nodal points in vicinity of boundary

For example, Fig. 63, A_1 and A_2 are nodal points close to the true boundary point A. Since $\phi_{A1} = \phi_A + (\partial\phi/\partial x)_A q$ and $\phi_{A2} = \phi_A - (\partial\phi/\partial x)_A p$, the stress function at the two nodal points can be determined. In solution for ϕ_b, the nonzero derivative is in the y direction, and the values at net points on either side of a boundary point in the vertical direction are determined. Values determined by both vertical and horizontal considerations are averaged. If the boundary is regarded as the nodal point nearest the true boundary, this procedure establishes nodal point values at the boundary and immediately inside the boundary. As the net is refined, the deviations between the nodal points and the true boundary becomes small.

Particular Solutions: Once the values of the stress function are established in the vicinity of the boundary, Equation 50 is applied to the other nodal points of the net. Temperature distribution enters into the equations for solution of ϕ_d only. For other solutions, temperature terms are omitted.

Finite-difference equations are solved in either of two ways. If the number of nodal points is small, the equations are solved simultaneously. Usually, however, the number of equations is large, and the relaxation procedure is used.

In the relaxation procedure, an estimate of stress function values at all nodal points is made. This estimate may be obtained by a preliminary course-network solution, an idealized solution, or a pure guess.

The correctness of a given set of nodal ϕ values is determined by applying Equation 50 at each net point. If the ϕ values are exact, the equations will be satisfied at each nodal point, and the value of the left side of each equation will be zero. If the estimate is not exact, the result will not be zero, and a residual will occur at each net point. The residual is equal to the result obtained by substituting the ϕ values into the left side of the equation. Changes are then introduced to reduce the residuals to approximately zero. This process is called relaxation.

A change of the stress function ϕ at one nodal point has the greatest effect on the residual at that nodal point, and lesser effects at other nodal points. The first nodal point considered is, therefore, the one with the largest residual. The value of ϕ_0 is altered there to reduce the residual to approximately zero, and as this value of ϕ is changed, the residuals at adjacent nodal points depends on the coefficient associated with that stress function in Equation 50.

For example, a change in ϕ_0 of unity changes the residual at 0 by 20, but the effect on the residual at point 1 is a change of -8, since the residual at 1 contains the term $-8\phi_0$.

Once the largest residual is diminished, the re-

maining highest residual is relaxed. The procedure is repeated until all residuals have been reduced to the desired zero approximation. When the residuals are reduced to the satisfactory low level, it may be the solution can be used as a guide to estimate ϕ values for a finer network. The process is repeated for any desired degree of accuracy.

COEFFICIENT FOR MULTIPLY-CONNECTED REGIONS: Four auxiliary problems with specified numerical boundary conditions are solved, and the solutions are combined according to Equation 51. Constants a, b, and c are arbitrary and do not affect the ability of Equation 51 to satisfy either the differential equations, or the boundary conditions of free surfaces, and are determined from conditions of continuity of the body.[6, 15, 16] Basically, the expressions for the differentials of displacement and rotation are integrated around any path enclosing a hole. If these integrals are single-valued, the value of the displacement or rotation is the same for both directions of the path, and the line integral is zero. The equation for single valuedness of rotation is

$$\int_p \frac{\partial \, \mathrm{del}^2 \phi}{\partial n} ds = -E\alpha \int_p \frac{\partial T}{\partial n} ds \qquad (52)$$

where the symbol $\int_p$ = line integral around any closed path enclosing the hole. The partial derivatives are taken normal to the boundary of the path. For convenience in integration, a path such as $pqrs$, Fig. 62, is chosen. The $\partial/\partial n$ becomes $\partial/\partial x$ and ds becomes dy along a vertical line pq, and the $\partial/\partial n$ becomes $\partial/\partial y$ and ds becomes dx along a horizontal line ps. Since the values for ϕ at each point are tabulated, the values at intermediate points are determined by interpolation. Line integrals for each auxiliary solution are then determined.

$$\frac{\partial \, \mathrm{del}^2 \phi_a}{\partial n} ds = \int_p^q \frac{\partial}{\partial x} (\mathrm{del}^2 \phi_a) dy + \int_q^r \frac{\partial}{\partial y} (\mathrm{del}^2 \phi_a) dx + \int_r^s \frac{\partial}{\partial y} (\mathrm{del}^2 \phi_a) dy + \int_s^p \frac{\partial}{\partial y} (\mathrm{del}^2 \phi_a) dx$$

Line integrals for other auxiliary solutions are obtained in the same way. For single-valuedness of rotation,

$$a \int_p \frac{\partial (\mathrm{del}^2 \phi_a)}{\partial n} ds + b \int_p \frac{\partial (\mathrm{del}^2 \phi_b)}{\partial n} ds + c \int_p \frac{\partial (\mathrm{del}^2 \phi_c)}{\partial n} ds + \int_p \frac{\partial (\mathrm{del}^2 \phi_d)}{\partial n} ds = -E\alpha \int_p \frac{\partial T}{\partial n} ds \qquad (53)$$

Equation 53 provides one of the equations for a, b, and c. Equations for displacements in the x and y direction are obtained from Equations 25 and 26.

The procedure for bodies with more than two surfaces is similar. Auxiliary solutions are obtained from non-zero derivative values on each boundary while on other boundaries, ϕ and the derivatives are maintained zero. If there are n interior boundaries, $3n$ separate solutions are obtained in addition to the particular integral which contains the temperature distribution. The complete solution is the particular solution plus each of the auxiliary solutions multiplied by a constant. The three conditions for single valuedness are then applied around each of the internal boundaries. Fig. 64 shows comparisons of stress calculations by relaxation and by exact closed form solutions.[16]

In the next article elastic stress determinations by collocation methods will be discussed.

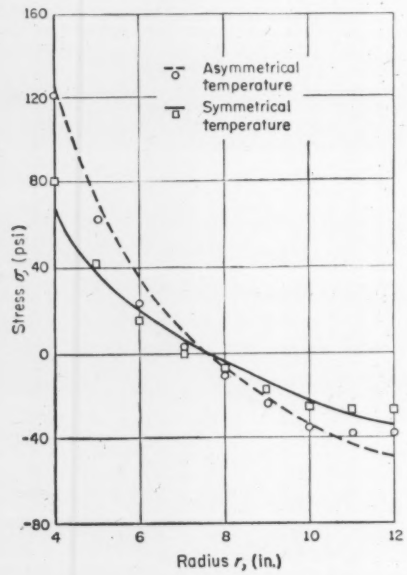

Fig. 64—Comparison of tangential stress calculated by relaxation with exact stresses for concentric cylinder with symmetrical and asymmetrical temperature distribution

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1. "Appraisal of Brittle Materials" June 12, 1958
2. "Quantitative Techniques for Brittle Materials" June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" August 7, 1958
4. "Causes of Fatigue in Ductile Materials" August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" September 4, 1958
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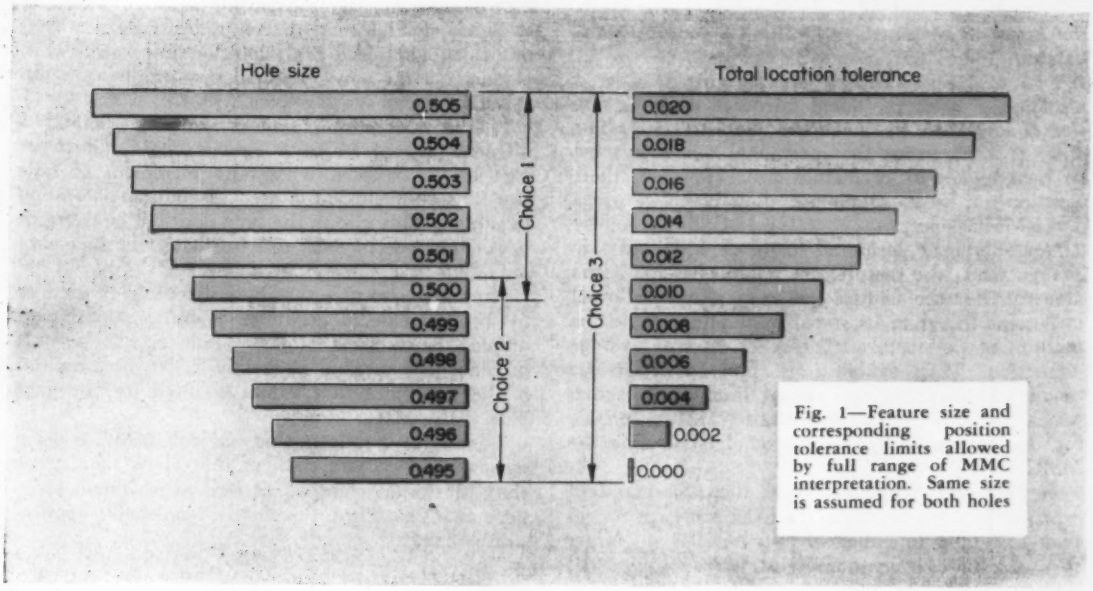

Fig. 1—Feature size and corresponding position tolerance limits allowed by full range of MMC interpretation. Same size is assumed for both holes

How to get the most from

SIZE-AND-LOCATION TOLERANCES

. . . an expansion of the maximum material concept outlined in American Drafting Standards Manual ASA Y14.5-1957

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HOW to relate position tolerance and feature tolerance is no new problem.

For example, tolerances are applied to the center distance between pins and mating holes. Tolerances are specified for hole and pin diameter. The arithmetic involved in obtaining the right fit may be easy enough, but often tolerances may be unnecessarily small. Or, often, dimensions may not be within tolerance and yet functional gaging proves that parts will fit satisfactorily.

Various methods for calling-out this interrelation of position and feature tolerances have been explored. One way, based upon the concept of maximum-material condition (MMC) is spelled out in

Maximum Material Condition

. . . by itself means that a feature of a finished product contains the maximum amount of material permitted by the toleranced size dimensions shown for that feature.

Thus for holes, slots, and other internal features, maximum material is the condition when these features are at their minimum allowable sizes, and for pads, shafts, bosses, thicknesses, and other external features, maximum material is the condition when these features are at their maximum sizes permitted by the toleranced dimensions.

As a general rule, tolerances of position are determined by the specified maximum material condition of mating features and in many cases the limits of location must be observed regardless of the actual finished sizes of the features concerned. However, in other applications, the limits of center distance may be exceeded if the features are not on their maximum material limits of size, because of the increased clearance between the mating features.

This, then, is the interpretation when the symbol MMC is used in conjunction with the location specification.

—ASA Y14.5-1957

the Appendix of American Drafting Standards Manual ASA Y14.5-1957.

Two MMC applications are recognized. One is provision of extra positional tolerance when feature size is less than its maximum material size. The other is a statement that positional tolerance must be held regardless of feature size. However, these cases do not fully explain nor allow complete usage of the MMC concept.

Not only may positional tolerance be allowed to change when the feature size approaches minimum material, but the feature size may also be allowed to become less than its stated minimum limit as the position of the feature approaches its true average dimension. This possibility also provides design decision and legalizes the use of functional gaging, which is the reason for introducing MMC. Including this interpretation would completely define the MMC concept.

For example, Appendix II of the ASA standard explains in some detail that a fixed pin gage proves that positional tolerance of two holes is no larger than the stated maximum print tolerance plus the difference between maximum and minimum hole size of each hole. This interpretation will insure assembly.

However, it is also true under the same circumstances that the gage proves the feature or hole size to be no smaller than the minimum hole per print minus one half the print location tolerance. This, of course, is the same reasoning that originally establishes the size of the gage pins.

In the ASA example of two holes, 0.500-0.505 diameter, spaced 1.995-2.005 apart, MMC allows the part to be accepted when any increment of hole size larger than 0.500 is used as additional location tolerance. This allows the hole positions to decrease to 1.990 and to increase to 2.010 when the hole sizes are 0.505.

Now it is also true that hole size could be smaller by any decrease in positional tolerance. In the example, the extreme of 0.495 hole size is possible provided the spacing is exactly 2.000, because this is the same size that would be used for the gage pins.

Therefore, it follows that the full MMC concept encloses feature size changes that allow more stock than maximum material, as well as positional tolerance changes. Thus, there are three possible application choices:

1. Permit positional tolerance to change (increase) as feature size departs from MMC.
2. Permit feature size to change (decrease) as positional tolerance approaches zero.
3. Permit positional tolerance and feature size both to change as their opposing factor departs from its worst assembly condition.

Corresponding dimensions of the example are listed in Fig. 1 for the three choices.

It must be remembered in MMC applications that function is always the determining factor. For instance, a design involving separate parts going into a pattern of holes, as pistons into cylinders, would require that specific fit between part and hole be maintained, although additional shift in hole location may be allowed without affecting the intended function. This choice of allowance could be applied to the drawing by the following note:

0.500-0.505 HOLES SPACED AS SHOWN MMC. LOCATION TOLERANCE MAY VARY.

The second choice would apply in certain alignment applications where it is necessary to maintain positional tolerance regardless of hole size. A suitable drawing note could be:

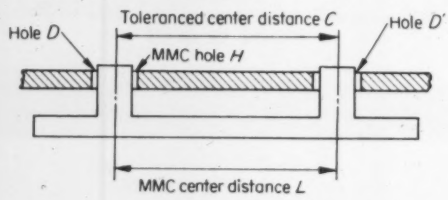
0.500-0.505 HOLES SPACED AS SHOWN MMC. HOLE SIZE MAY VARY.

The third choice could be used in such areas as standard bolt clearance hole patterns. Drawing callout could be:

0.500-0.505 HOLES SPACED AS SHOWN MMC. LOCATION TOLERANCE AND HOLE SIZE MAY VARY.

The MMC concept can also be applied where center distance is given as basic, or as true position, and the holes are located within radius R, or diameter D, of basic position. Determination of maximum center line shift of the hole and of minimum hole size for this dimensioning is illustrated in Fig. 2.

Toleranced Center Distance



Choice 1

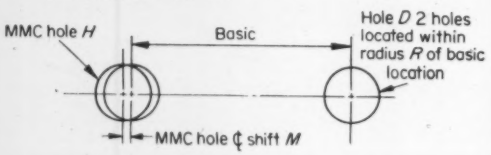
$$L_{min} = C_{min} - \frac{D_{max} - D_{min}}{2} + \frac{D'_{max} - D'_{min}}{2}$$

$$L_{max} = C_{max} + \frac{D_{max} - D_{min}}{2} + \frac{D'_{max} - D'_{min}}{2}$$

Choice 2

$$H_{min} = D_{min} - \frac{C_{max} - C_{min}}{2}$$

Basic Center Distance



Choice 1

$$M = R + \frac{D_{max} - D_{min}}{2}$$

Choice 2

$$H_{min} = D_{min} - 2R$$

Fig. 2—Determination of extreme values allowed by the MMC concept

PREFERRED PINION SIZES

for precision gearing

Tables of dimensions for fine-pitch pinions with diameters enlarged to avoid undercutting or interference

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FINE-PITCH gears with small numbers of teeth must be enlarged to avoid undercutting in generation or interference in meshing action. For the 20-deg involute fine-pitch system, this condition applies to gears with fewer than 18 teeth.

Dimensions of enlarged (long-addendum) 20-deg pinions have been established in the 7 to 17 tooth range by an ASA standard.[1] This article presents tables of dimensions and values necessary for complete specification of such enlarged pinions in a preferred series of diametral pitches selected on the basis of practical production considerations. These data were set up to augment present gear standards. A companion article[2] detailing dimensions of a series of preferred gear sizes appeared earlier.

Design Data: Table 1 provides dimensions necessary for size specification of enlarged 20-deg fine-pitch involute pinions with 7 to 17 teeth. For each basic size, dimensions are given for six diametral pitches selected by Westinghouse Air Arm Div. as a preferred series: 24, 32, 48, 64, 96 and 120. Data include values of nominal testing radius R_t, nominal measurement over pins M, and thickness factor K_m to aid and simplify backlash calculations. In addition, pertinent dimensional information for design of gears to mesh at standard or enlarged center distances is given.

Data for quality specification of these enlarged pinions are given in Table 2. These include values and tolerances for changes in circular tooth thickness and testing radii to meet the requirements of standard backlash and quality classifications.

Examples: Develop complete design specification for a 64 diametral pitch enlarged 20-deg involute pinion with 10 teeth. Pinion must be of Precision 1 quality with sufficient reduction in tooth thickness to give Class B backlash when meshed with a

Nomenclature

C = Standard center distance, in.
ΔC = Increase in standard center distance required for proper meshing action between enlarged pinion and standard gear, in.
D_o = Standard outside diameter of gear, in.
ΔD_o = Reduction in standard outside diameter of gear required to maintain standard center distance with enlarged pinion, in.
d = Pitch diameter of pinion, in.
d_m = Pin diameter, in.
d_o = Outside diameter of pinion, in.
K_m = Thickness factor
= Ratio of change in pin measurement to change in circular thickness
N_{min} = Minimum number of teeth in reduced-size gear meshing with enlarged pinion
M_{nom} = Standard measurement over pins, in.
n = Number of teeth in pinion
P = Diametral pitch
$R_{t,\,nom}$ = Nominal testing radius, in.
ΔR_t = Change in center distance or testing radius due to backlash, in.
T = Nominal circular tooth thickness of reduced-size gear at pitch diameter, in.
t_{nom} = Nominal circular tooth thickness of pinion at pitch diameter, in.
ΔT = Reduction in circular tooth thickness of pinion or gear to provide required backlash, in.

[1]References are tabulated at end of article.

Table 1—Enlarged-Pinion Dimensions
(20-Deg. Fine-Pitch Involute System)

	Enlarged Pinion								Gear			
										Reduced D_o		Std. D_o
n	P	d	d_o	t_{nom}	$R_{t,\ nom}$	M_{nom}	K_M	d_{wt}	N_{min}	$-\Delta D_o$	T	$+\Delta C$
7	24	0.2917	0.4095	0.0834	0.1705	0.4300	1.45	0.0800	42	0.0492	0.0475	0.0246
	32	.2188	.3071	.0625	.1278	.3225	1.45	.0600		.0369	.0357	.0185
	48	.1458	.2048	.0417	.0865	.2150	1.45	.0400		.0246	.0238	.0123
	64	.1094	.1536	.0313	.0640	.1613	1.45	.0300		.0185	.0178	.0092
	96	.0729	.1024	.0208	.0426	.1075	1.45	.0200		.0123	.0119	.0062
	120	.0583	.0819	.0167	.0341	.0860	1.45	.0160		.0098	.0095	.0049
8	24	0.3333	0.4531	0.0816	0.1889	0.4797	1.51	0.0800	39	0.0443	0.0493	0.0222
	32	.2500	.3398	.0612	.1416	.3598	1.51	.0600		.0333	.0370	.0166
	48	.1667	.2265	.0408	.0944	.2398	1.51	.0400		.0222	.0247	.0111
	64	.1250	.1699	.0306	.0708	.1799	1.51	.0300		.0166	.0185	.0083
	96	.0833	.1133	.0204	.0472	.1200	1.51	.0200		.0111	.0123	.0055
	120	.0667	.0906	.0163	.0377	.0959	1.51	.0160		.0089	.0099	.0044
9	24	0.3750	0.4933	0.0798	0.2072	0.5134	1.57	0.0800	36	0.0395	0.0511	0.0197
	32	.2813	.3699	.0599	.1555	.3850	1.57	.0600		.0296	.0383	.0148
	48	.1875	.2466	.0399	.1036	.2566	1.57	.0400		.0197	.0255	.0099
	64	.1406	.1850	.0299	.0777	.1926	1.57	.0300		.0148	.0192	.0074
	96	.0938	.1233	.0200	.0519	.1284	1.57	.0200		.0099	.0128	.0049
	120	.0750	.0987	.0160	.0415	.1026	1.57	.0160		.0079	.0102	.0039
10	24	0.4167	0.5346	0.0780	0.2256	0.5601	1.62	0.0800	33	0.0346	0.0529	0.0173
	32	.3125	.4009	.0585	.1692	.4200	1.62	.0600		.0259	.0396	.0130
	48	.2083	.2673	.0390	.1128	.2800	1.62	.0400		.0173	.0264	.0086
	64	.1563	.2005	.0293	.0847	.2101	1.62	.0300		.0130	.0198	.0065
	96	.1042	.1336	.0195	.0564	.1401	1.62	.0200		.0087	.0132	.0043
	120	.0833	.1069	.0156	.0451	.1120	1.62	.0160		.0069	.0106	.0039
11	24	0.4583	0.5714	0.0763	0.2441	0.5945	1.68	0.0800	30	0.0297	0.0546	0.0149
	32	.3438	.4285	.0572	.1830	.4459	1.68	.0600		.0223	.0410	.0111
	48	.2292	.2857	.0381	.1220	.2972	1.68	.0400		.0149	.0273	.0074
	64	.1719	.2143	.0286	.0915	.2230	1.68	.0300		.0111	.0205	.0056
	96	.1146	.1428	.0191	.0611	.1487	1.68	.0200		.0074	.0137	.0037
	120	.0917	.1143	.0152	.0488	.1189	1.68	.0160		.0059	.0109	.0030
12	24	0.5000	0.6082	0.0745	0.2624	0.6393	1.73	0.0800	27	0.0248	0.0564	0.0124
	32	.3750	.4561	.0559	.1969	.4795	1.73	.0600		.0186	.0423	.0093
	48	.2500	.3041	.0372	.1312	.3196	1.73	.0400		.0124	.0282	.0062
	64	.1875	.2281	.0279	.0984	.2398	1.73	.0300		.0093	.0212	.0047
	96	.1250	.1520	.0186	.0656	.1599	1.73	.0200		.0062	.0141	.0031
	120	.1000	.1216	.0149	.0525	.1278	1.73	.0160		.0050	.0113	.0025
13	24	0.5417	0.6450	0.0727	0.2808	0.6742	1.79	0.0800	25	0.0200	0.0582	0.0100
	32	.4063	.4837	.0545	.2106	.5056	1.79	.0600		.0150	.0436	.0075
	48	.2708	.3224	.0364	.1405	.3370	1.79	.0400		.0100	.0291	.0050
	64	.2031	.2419	.0273	.1053	.2529	1.79	.0300		.0075	.0218	.0037
	96	.1354	.1613	.0182	.0702	.1686	1.79	.0200		.0050	.0146	.0025
	120	.1083	.1289	.0145	.0561	.1348	1.79	.0160		.0040	.0116	.0020
14	24	0.5833	0.6818	0.0710	0.2993	0.7177	1.84	0.0800	23	0.0151	0.0600	0.0076
	32	.4375	.5113	.0532	.2244	.5382	1.84	.0600		.0113	.0450	.0057
	48	.2917	.3408	.0355	.1497	.3588	1.84	.0400		.0075	.0300	.0038
	64	.2188	.2557	.0266	.1122	.2692	1.84	.0300		.0057	.0225	.0028
	96	.1458	.1705	.0177	.0747	.1795	1.84	.0200		.0038	.0150	.0019
	120	.1167	.1363	.0142	.0599	.1435	1.84	.0160		.0030	.0120	.0015
15	24	0.6250	0.7186	0.0692	0.3177	0.7529	1.89	0.0800	21	0.0102	0.0617	0.0051
	32	.4688	.5389	.0519	.2382	.5646	1.89	.0600		.0077	.0463	.0038
	48	.3125	.3592	.0346	.1588	.3763	1.89	.0400		.0051	.0309	.0026
	64	.2344	.2695	.0259	.1191	.2824	1.89	.0300		.0038	.0232	.0019
	96	.1563	.1797	.0173	.0794	.1883	1.89	.0200		.0026	.0164	.0013
	120	.1250	.1437	.0138	.0635	.1505	1.89	.0160		.0020	.0123	.0010
16	24	0.6667	0.7554	0.0674	0.3360	0.7953	1.95	0.0800	19	0.0054	0.0635	0.0027
	32	.5000	.5665	.0505	.2519	.5964	1.95	.0600		.0040	.0476	.0020
	48	.3333	.3776	.0337	.1680	.3975	1.95	.0400		.0027	.0317	.0013
	64	.2500	.2833	.0253	.1260	.2983	1.95	.0300		.0020	.0238	.0010
	96	.1667	.1889	.0169	.0841	.1989	1.95	.0200		.0013	.0159	.0007
	120	.1333	.1510	.0135	.0673	.1590	1.95	.0160		.0011	.0127	.0005
17	24	0.7083	0.7922	0.0656	0.3544	0.8306	2.00	0.0800	18	0.0005	0.0653	0.0002
	32	.5313	.5941	.0492	.2658	.6229	2.00	.0600		.0004	.0490	.0002
	48	.3542	.3960	.0328	.1772	.4152	2.00	.0400		.0002	.0326	.0001
	64	.2656	.2971	.0246	.1329	.3115	2.00	.0300		.0002	.0245	.0001
	96	.1771	.1981	.0164	.0886	.2077	2.00	.0200		.0001	.0163	.0001
	120	.1417	.1584	.0131	.0709	.1660	2.00	.0160		.0001	.0131	.0001

Table 2—Gear-Size Tolerances*

Backlash Class	Diametral Pitch	Circular Tooth Thickness†		Testing Radius‡													
				Commercial Quality								Precision Quality					
				1		2		3		4		1		2		3	
		ΔT	Tol.	ΔR_t	Tol.	ΔR_t	Tol.	ΔR_t	Tol.	ΔR_t	Tol.	ΔR_t	Tol.	ΔR_t	Tol.	ΔR_t	Tol.
	20— 45	0.0020	0.0010	0.0027	0.0074	0.0027	0.0054	0.0027	0.0034	0.0027	0.0029	0.0027	0.0024	0.0027	0.0019	0.0027	0.0017
A	46— 70	.0015	.0010	.0021	.0073	.0021	.0053	.0021	.0033	.0021	.0028	.0021	.0023	.0021	.0018	.0021	.0016
	71— 90	.0010	.0008	.0014	.0071	.0014	.0051	.0014	.0031	.0014	.0026	.0014	.0021	.0014	.0016	.0014	.0013
	20— 60	.0010	.0010	.0014	.0074	.0014	.0054	.0014	.0034	.0014	.0029	.0014	.0024	.0014	.0019	.0014	.0016
B	61—120	.0008	.0008	.0010	.0071	.0010	.0051	.0010	.0031	.0010	.0026	.0010	.0021	.0010	.0016	.0010	.0013
	121—200	.0005	.0005	.0007	.0067	.0007	.0047	.0007	.0027	.0007	.0022	.0007	.0017	.0007	.0012	.0007	.0009
	20— 60	.0005	.0005	.0007	.0067	.0007	.0047	.0007	.0027	.0007	.0022	.0007	.0017	.0007	.0012	.0007	.0009
C	61—120	.0004	.0004	.0005	.0065	.0005	.0045	.0005	.0025	.0005	.0020	.0005	.0015	.0005	.0010	.0005	.0008
	121—200	.0003	.0003	.0004	.0063	.0004	.0043	.0004	.0023	.0004	.0018	.0004	.0013	.0004	.0008	.0004	.0006
D	20—200	.0000	.0002	.0000	.0063	.0000	.0043	.0000	.0023	.0000	.0017	.0000	.0013	.0000	.0008	.0000	.0005

*Values are based on equal division of backlash between gears in mesh.
†Circular tooth thickness = (Std. tooth thickness $-$ ΔT) $-$ Tolerance.
‡Testing radius R_t = ($R_{t\ nom}$ $-$ ΔR_t) $-$ Tolerance.

gear. Tooth thickness reduction is to be equally divided between pinion and gear.

From Table 1, for $P = 64$ and $n = 10$, find $d = 0.1563$ in., $d_o = 0.2005$ in., $t_{nom} = 0.0293$ in., $R_{t,nom} = 0.0847$ in., $M_{nom} = 0.2101$ in., $K_m = 1.62$ and $d_m = 0.0300$ in.

From Table 2, reduction in tooth thickness required for each gear in a meshing pair to give Class B backlash where $P = 64$ is $\Delta T = 0.0008$ in. with a tolerance of 0.0008 in. Corresponding reduction in the standard measurement over pins is given by the product of K_m and ΔT. Thus, the reduced measurement over pins, M, is:

$$M = [M_{nom} - K_M\ (\Delta T)] - K_M\ (\text{tolerance on } \Delta T)$$
$$= [0.2101 - 1.62\ (0.0008)] - 1.62\ (0.0008)$$
$$= 0.2088 - 0.0013 \text{ in.}$$

Maximum circular tooth thickness $t = t_{nom} - \Delta T = 0.0293 - 0.0008 = 0.0285$ in.

Also, from Table 2 for Precision 1 class gears of 64 diametral pitch, change in center distance or testing radius due to backlash, $\Delta R_t = 0.0010$ in. per gear with a tolerance of 0.0021 in. Corrected testing radius, R_t, is given by

$$R_t = (R_{t.\,nom} - \Delta R_t) - (\text{tolerance on } \Delta R_t)$$
$$= (0.0847 - 0.0010) - 0.0021$$
$$= 0.0837 - 0.0021 \text{ in.}$$

Complete specification for this enlarged pinion is shown in Fig. 1.

Assume now that a 64 diametral pitch gear with 64 teeth is to mesh with this pinion. Standard outside diameter $D_o = 1.0313$ in. and standard center distance $C = 0.5782$ in.

Since the pinion is enlarged, gear size must be reduced if a standard center distance is to be maintained. From Table 1, amount of reduction required in the gear OD is $\Delta D_o = 0.0130$ in., which gives outside diameter of reduced gear $D_{o\,red} = 1.0313 - 0.0130 = 1.0183$ in. Also, from Table 1, nominal circular tooth thickness of the reduced gear at the pitch diameter is $T = 0.0198$ in. This dimension, like that of the pinion, must be reduced to meet backlash requirements for the meshing pair.

If reduction of the gear OD is impractical or undesirable and a standard gear must be meshed with the enlarged pinion, center distance must be increased. From Table 2, the increment that must be added to the standard center distance for proper meshing action is $\Delta C = 0.0065$ in. Enlarged or corrected center distance $C_{corr} = C + \Delta C = 0.5782 + 0.0065 = 0.5847$ in.

REFERENCES

1. *American Standard 20-Degree Involute Fine-Pitch System*—ASA B6.7-1956 (AGMA 273.04).
2. Gustav A. Larson—"Preferred Gear Sizes," MACHINE DESIGN, Vol. 29, No. 16, August 8, 1957, pp. 113-117. (Also, *Machine Design Data Sheets*, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio, 1957, pp. 61-65.)

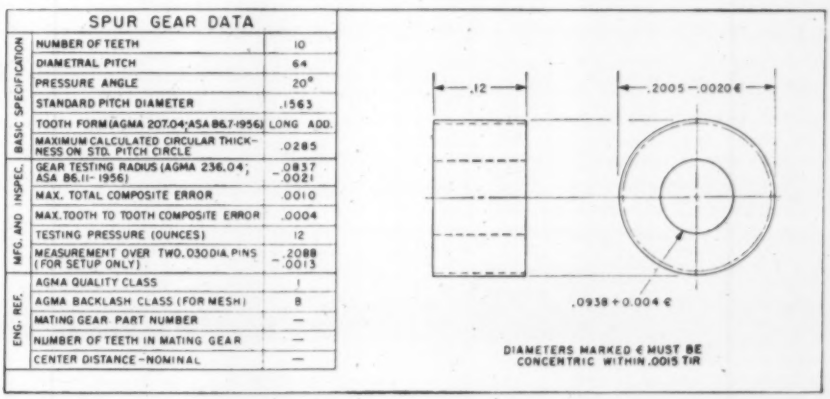
SPUR GEAR DATA
BASIC SPECIFICATION
NUMBER OF TEETH 10
DIAMETRAL PITCH 64
PRESSURE ANGLE 20°
STANDARD PITCH DIAMETER .1563
TOOTH FORM (AGMA 207.04-ASA B6.7-1956) LONG ADD.
MAXIMUM CALCULATED CIRCULAR THICKNESS ON STD. PITCH CIRCLE .0285
MFG. AND INSPEC.
GEAR TESTING RADIUS (AGMA 236.04; ASA B6.11-1956) .0837 -.0021
MAX. TOTAL COMPOSITE ERROR .0010
MAX. TOOTH TO TOOTH COMPOSITE ERROR .0004
TESTING PRESSURE (OUNCES) 12
MEASUREMENT OVER TWO .030 DIA. PINS (FOR SETUP ONLY) .2088 -.0013
ENG. REF.
AGMA QUALITY CLASS 1
AGMA BACKLASH CLASS (FOR MESH) B
MATING GEAR PART NUMBER —
NUMBER OF TEETH IN MATING GEAR —
CENTER DISTANCE—NOMINAL —
.12
.2005 -.0020 ℄
.0938 +0.004 ℄
DIAMETERS MARKED ℄ MUST BE CONCENTRIC WITHIN .001 5 TIR

Fig. 1—Typical specification drawing for enlarged 20-deg involute pinion with 10 teeth of 64 diametral pitch

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DESIGN ABSTRACTS

electrical

The Silicon Controlled Rectifier

W. D. Cockrell, General Electric Co.

Characteristics of a new, electrical "power valve" for semiconductor thyratrons. Advantages of the new control include small size, low internal voltage loss, no standby-power loss, and no filament. In addition, the silicon controlled rectifier contains no liquid mercury or gas. Equipment designed is simplified since operation is independent of position or attitude. Ratings of presently available control sizes are 16 and 50 amps. Devices in which the rectifier finds application include: Motors from fractional through integral hp sizes, resistance welders and other precision ac switches, generator regulator and excitors, speed regulators, position regulators, program-controlled equipment, and heating controls. Generally, as a semi-conductor, the device is best adapted for use with transistor-controlled circuits.

AIEE paper, Tenth Annual AIEE Machine Tool Conference, Hartford, Conn., October, 1958; 11 pp.

A Power Servo For Automatic Machines

J. A. Hudak, Reliance Electric and Engineering Co.

Design features of a gain stage and actuator device in the form of a dc, servo-type motor. Function of these elements in automatic machine operation is illustrated and described in a typical servo loop diagram. Ratio of torque to inertia is a valid indication of ability of a motor to respond. Design of the new actuator improved this ratio by 5 to 1 compared to that of a standard machine. Contributing to this improvement is an armature feature which minimizes inertia and facilitates smooth rotation at low speed. The system provides adequate power for a majority of machine applications, ready adaptability to a variety of reference and feedback signals, adjustable speed to allow optimum programming of the machine, and adequate response for machine-tool servo applications. The major limitation on performance is frequency of applied power.

AIEE paper, Tenth Annual AIEE Machine Tool Conference, Hartford, Conn., October, 1958; 7 pp.

Tubes and Transistors In Machine Control

H. P. Grossimon, Concord Controls Inc.

Analysis of advantages and disadvantages of tubes and transistors in the light of industrial control requirements, with specific comparisons of performance, reliability, and costs. Included are explanations of basic principles of operation of the semiconductor diode and transistor. Devices which prove useful to circuit designers and others interested in machine-control systems include the transistor, spacistor, and control rectifier which are either available now or will be in the near future. Design costs are higher for transistor systems but are somewhat offset by savings in cooling equipment and cabinetry. Arguments in favor of both tubes and transistors are evaluated. Tubes are more versatile performers than transistors and many more tube types are available than transistor types. Tube cost is low and reliability good. The transistor, on the other hand, dissipates less input power than the tubes, is a more efficient power-control device, and offers a means of extending system reliability.

AIEE paper, Tenth Annual AIEE Machine Tool Conference, Hartford, Conn., October, 1958; 23 pp.

materials

A High-Damping Magnesium Alloy

G. F. Weissman and W. Babington, Bell Telephone Laboratories

Results of damping studies on several magnesium alloys using flat cantilever specimens stressed in bending. Specific damping capacity of the alloys was established as a function of strain relative to the strain distribution of the test specimens. Resonance application factor is determined analytically and compared with the results of vibrations tests. One magnesium alloy, containing nominally 0.6 per cent zirconium, shows a very high damping capacity combined with adequate mechanical properties. From these data, resonance amplitudes of any simple structure can be predicted analytically. In the case of complicated structures, relative damping performance of two different alloys can be determined analytically. Alloy damping in both sand-cast and die-cast conditions are compared. Damping properties are not affected by machining, aging, or finishing. Heat treating does not affect unmachined alloys, but a reduction in damping is observed after heat treat-

ing machined samples. Sand-cast alloys show better damping properties than die cast materials. Resonance amplitudes of sand castings of Mg-Zr alloy show a reduction to approximately 25 to 40 per cent of those occurring in Mg-Al-Zn alloy castings depending on existing strain distribution.

Proceedings of the Fourteenth Annual Convention of the Magnesium Association, Detroit, Mich., October, 1958; 22 pp.

Glass as a Structural Member

G. B. Watkins, Libbey-Owens-Ford Glass Co.

A complete "handbook" containing data on types and compositions of glasses, classifications, mechanical-strength formulas, physical and mechanical properties, tempered or heat-strengthened glass, effects of surface damage, types of transparent laminated glass, curved safety glass, and laminated safety glass for automotive and aircraft requirements. Tensile strength of well-annealed glass is approximately 6000 psi, and its compression strength is many times greater. It is generally believed that glass is infinitely strong in compression, and failure under compression loading is due to a tensional component of the compressive stress. Identically prepared specimens of glass show as much as 200 to 300 percent variation in breaking loads. Some emphasis is placed on glass as a structural member in automobile bodies. However, design data is applicable to any field of endeavor in which glass plays a significant part. Development of a transparent material which can be laminated with glass to form a composite structural member is expected.

SAE paper 11R, SAE Annual Meeting, Detroit, Mich., January 1959; 25 pp.

Applications of Solid Polyurethane

A. H. Grim, Disogrin Industries Inc.

A series of case histories which shows successful application of solid polyurethane components. This material has excellent resistance to abrasives and hydraulic fluids and can be readily bonded to metal surfaces of various contours. Tensile strengths of various formulations range from 4000 to 7000 psi. These synthetic elastomers combine unusual combinations of properties which can be varied to suit particular applications. For example, a hardness of 93 to 96 Shore durometer, A scale, can be combined with a 4500 to 5500-psi tensile strength and a 450 to 500 per cent elongation. Many finished parts can be stamped from sheets of polyurethane and cold bonded to metals with suitable adhesives. The high hysteresis of polyurethane makes thin diaphragms possible in low-temperature applications. Enough heat is generated in a few flexing cycles to prevent brittle fracture and subsequent failure of the diaphragm. A brief review of the basic processes for producing solid polyurethanes is included.

ASME paper, ASME Annual Meeting, New York, December, 1958; 7 pp.

mechanical

Evolution of Hydraulic Turbines

T. Danel, Societe Grenobloise d'etudes et d'applications Hydrauliques (France)

A brief survey of some of the most striking developments in hydraulic turbines in recent years. Certain aspects of mechanical design are emphasized. To conventional turbines, such as the impulse and fixed-blade types, various types have been added in recent years. Of the new types, probably the most important is the Bulb or Tube turbine which is briefly described. One design trend, for example, is characterized by a gradual replacement of separate bucket impellers by integrally cast ones. Also, the number of jets on multiple-jet units is now often as high as four, five or six with the same peak efficiencies as the best single-jet units. Features of the modern Bulb unit have paved the way for development of tidal power. To be efficient, tidal power requires units which can be operated as turbines and pumps. The Bulb unit lends itself very well to such a very difficult type of operation and several new plants are being planned to take advantage of the new possibilities of the machine.

Prepared for the Institution of Mechanical Engineers (Great Britain); 12 pp.

Three-Dimensional Flow In Axial Pumps and Fans

S. Mikhail, Cairo University

Results of research on three-dimensional flow in nonfree-vortex axial pumps and fans. The major feature of a free-vortex design is that circulation along each blade is constant, and stream surfaces of the flow are concentric circular cylinders of the same radius before and after the rotor. A rigorous solution of the linearized partial differential equation describes the flow in nonfree-vortex machines. The solution determines stream surfaces of the mean flow for the case of a thin rotor disc. In the design of new machines, distribution of blade loading is not known unless the effective free-stream flow pattern is determined. Blades must then be placed to supply the forces corresponding to prescribed motions of fluid far upstream and downstream of the rotor. This paper attempts to solve this problem by replacing the rotor by a thin rotor disc of infinitesimal axial thickness with an infinite number of blades and situated at the center of gravity of blade loading. The problem simplifies, then, into one of finding the flow pattern which would coincide with flow motions at the upstream and downstream regions of the rotor and which gives continuous velocity components at the thin rotor disc. With the proper choice of design variables, it is possible to design nonfree-vortex machines in which drawbacks of the three-dimensional nature of flow can be kept to a minimum.

Prepared for the Institute of Mechanical Engineers (Great Britain).

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for Design Executives

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Data Processing

Low cost system of punched card data processing for small businesses is described in illustrated Folder U1638. Consisting of four basic pieces of equipment, system is suited for production and inventory control, payroll, accounts receivable, and sales analysis. 6 pages. Sperry Rand Corp., Remington Rand Univac Div., 315 Fourth Ave., New York 10, N. Y. D

Circle 581 on Page 19

Filled Teflon Bearings

Seven styles of filled Teflon bearing materials in the Chempro line are listed in Technical Bulletin CP-558. They have good wearing qualities and are less subject to thermal expansion and cold flow than pure Teflon. Application data are given. 1 page. Chemical & Power Products, Inc., 11 Broadway, New York 4, N. Y. D

Circle 582 on Page 19

Pressure Reducing Valve

Atlas Fig. 1910 Type E reducing valve featured in Catalog Section 1 is designed for initial pressures up to 300 psi with gas, oil, or water. Outlet or regulated spring ranges are 5-35, 20-60, and 40-90 psi. 2 pages. Atlas Valve Co., 280 South St., Newark, N. J. D

Circle 583 on Page 19

Predetermined Counter

Features, specifications, installation, and applications of Countron predetermined counter are reviewed in brochure. Counters control sequential operations of high speed machinery, packaging and batching of parts and cartons, cutting of stock to exact lengths, timing, and liquid metering. 14 pages. Hobson Miller Machinery Corp., 280 Lafayette St., New York 12, N. Y. D

Circle 584 on Page 19

Cleaning & Phosphating

"How to Clean and Phosphate Metals in One Operation at Low Cost" is descriptive title of illustrated bulletin which covers the what, why, where, and how of the steam cleaner phosphating process. Value of phosphate protection of metal is discussed. 16 pages. Malsbary Mfg. Co., 845 92nd Ave., Oakland 3, Calif. M

Circle 585 on Page 19

Single-Phase Motors

Available in ratings of 3/4 to 20 hp, new line of single-phase motors covered in Bulletin 470-B includes open protected, totally enclosed fan cooled, and explosionproof frames. Motors are particularly suited for use in damp, dirty, or corrosive atmospheres. Robbins & Myers, Inc., Motor Div., Springfield, Ohio. G

Circle 586 on Page 19

Protective Coatings

Revised Bulletin 100 on protective coatings presents a breakdown of four classifications of corrosive conditions. Simplified chart facilitates selection of coatings according to service requirements. 4 pages. Carboline Co., 32 Hanley Industrial Court, St. Louis 17, Mo. I

Circle 587 on Page 19

Immersion Heaters

Therm-X-Red immersion heaters introduced in folder are offered in standard, thermostat, and remote thermostat models. These steel, stainless steel, and translucent fused quartz heaters have heat ranges of 50 to 250° F. 6 pages. N. J. Thermex Co., 535-537 Bergen St., Harrison, N. J. D

Circle 588 on Page 19

Temperature Monitors

Operation, specifications, connection, and installation of Omniguard Model 310 temperature monitor unit and Model 311 indicator are reviewed in Catalog 3036 C. Also covered are resistance temperature detectors used wherever temperatures are measured, recorded or controlled. 26 pages. Thomas A. Edison Industries, West Orange, N. J. D

Circle 589 on Page 19

Brazing Alloys

Palora, Nicoro 80, and Nicusil 3 are featured in Catalog V-124 describing the line of Wesgo ultrahigh purity, low vapor pressure brazing alloys for vacuum systems. A characteristics chart for brazing filler metals is included. 4 pages. Western Gold & Platinum Co., Belmont, Calif. M

Circle 590 on Page 19

Voltage Regulator

Technical data Bulletin 5.041 is descriptive of the new 4K Regohm voltage regulator. This compact unit can regulate generator sets rated up to 600 kva at 1800 rpm. 2 pages. Electric Regulator Co., Pearl St., Norwalk, Conn. B

Circle 591 on Page 19

Phenolic Products

G-E's line of phenolic resins, varnishes, and molding powders are described as to features, special properties, and technical data in Booklet CDC-358. 8 pages. General Electric Co., Chemical & Metallurgical Div., Pittsfield, Mass. B

Circle 592 on Page 19

Belt Conveyor Idlers

Engineering selection data on five new series and 23 types of belt conveyor idlers are detailed in Book 2716. It lists the complete line of idlers for belt widths from 14 to 84 in. All idlers have inverted angle bases and removable steel retainer clips that hold rolls in position. 40 pages. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill. J

Circle 593 on Page 19

Ceramic Capacitors

The "Ceramic Capacitor Cross-Reference" lists over 600 Centralab ceramic capacitors by type and rating. Covered are discs and tubulars, high voltage discs, dual capacitors, buffer capacitors, low voltage capacitors, as well as stand-off and feed through, transmitting, and trimmer capacitors. 16 pages. Globe-Union Inc., Centralab Div., 900 E. Keefe Ave., Milwaukee 1, Wis. K

Circle 594 on Page 19

Germanium Transistors

Mechanical data, maximum ratings, typical characteristics, and design features of PNP diffused-base germanium transistors are presented in Bulletin DL-S. 2 pages. Texas Instruments Inc., Box 312, 13500 N. Central Expressway, Dallas, Tex. P

Circle 595 on Page 19

Pressure Instruments

Pressure instruments for indicating, recording, controlling, and transmitting are subject of Specifications Sheets 11-1451P-1 to 5. Instruments have corrosionproof glass fiber cases and are described as to features, performance, and operational limits. 10 pages. Fischer & Porter Co., 843 Jacksonville Rd., Hatboro, Pa. E

Circle 596 on Page 19

Nickel-Base Alloy

Excellent resistance to corrosion with good strength at high temperatures are combined in Hastelloy alloy B, subject of Booklet F-30,127. Alloy retains over two-thirds of its yield strength at 1600° F. 12 pages. Haynes Stellite Co., Kokomo, Ind. C

Circle 597 on Page 19

Small Panel Instruments

G-E's "big look" in small panel instruments is described in Folder GEA-6678. The 2½ and 3½-in. alternating and direct-current instruments fit into the conventional panel spaces, but feature excellent readability. 6 pages. General Electric Co., Schnectady 5, N. Y. C

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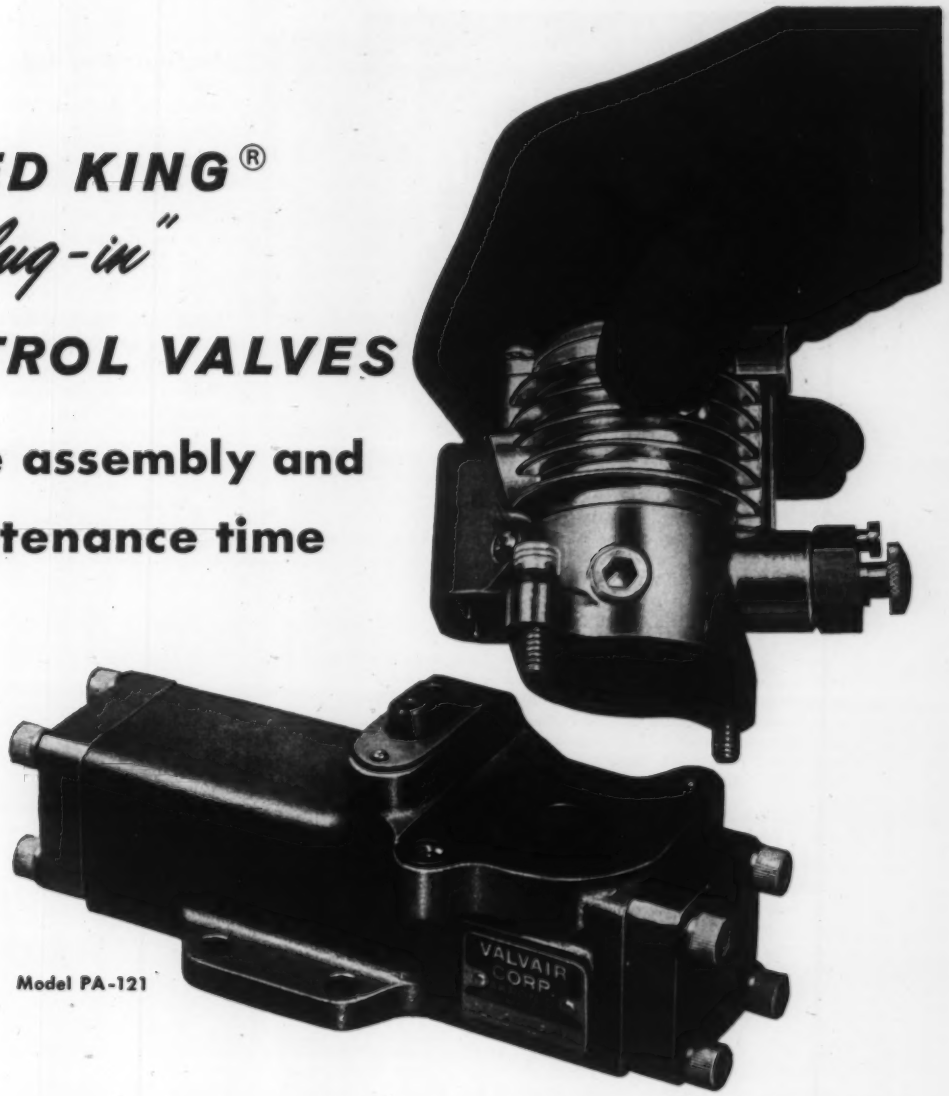


Model PA-121

Built-in plugs and connectors in Valvair's new ¼ in. Speed King 4-way control valves complete electrical circuits *automatically*... reduce assembly and maintenance time to a cost-cutting minimum! Permanent electrical connections are made in manifold or sub-base at assembly... then valves and pilots are plugged in... bolted down. There's no need to disturb equipment wiring for quick in-service maintenance!

Navy M bronze and stainless steel components assure 20 million cycle-plus dependability. Interchangeable pilot, with coil guaranteed against burn-out for life of valve, fits any plug-in Speed King. Coils for ac or dc, any voltage ... 35—200 psi range... optional manual override... ¼ in. cylinder ports... 2 or 3 station manifold with common inlet, exhaust and conduit ports, or sub-base mounted... valve meets JIC standards!

Whether you build or operate machines, you'll find that Valvair plug-in control valves set new standards of adaptability, performance and economy!

Write for Bulletin D-58. Address Dept. MD 359, Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio

Representatives in Principal Cities

Valvair AKRON 11, OHIO

Other INDUSTRIAL DIVISIONS of IBEC: The Sinclair-Collins Valve Co. The Bellows Co., Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio

8000

SMART DESIGN ENGINEERS SUBMIT THEIR

CLUTCH AND BRAKE

PROBLEMS TO US

They do it every day . . . because they save time, engineering costs, and design headaches by using our PROVEN, standardized clutch and brake units.

Shown here are the basic types . . . including the Industry's most successful ELECTRIC Clutches and Brakes . . . available from stock in a full range of sizes, and ready to go to work in your equipment with assured performance.

Equally valuable is the advice and practical help on special problems available to you by calling our experienced engineering department. It usually pays to "TALK MAXITORQ" first.

SERIES 8000 ELECTRIC CLUTCHES AND BRAKES

PROVED design, Floating Disc action is fast and positive, with no heating or drag in neutral. Compact, simple, with few moving parts. For WET or DRY operation: Electrical operating unit DOES NOT REVOLVE; no brushes or slip rings. Uses easily replaced standard Disc-Pac. Requires no adjustment. Wide range of standard sizes, single and double types. All sizes rated 80 watts, operate on 110 V.A.C., rectified to 90 V.D.C. Other voltages on special order.

SERIES 9000 ELECTRIC CLUTCHES AND BRAKES

Operation is induced entirely by magnetic flux which provides fast response. There are no brushes, slip rings, stressed parts or wiring problems. Flexibility of control, compact design, drag-free neutral, ease of installation, suggest a wide range of applications from simple machines to punched tape or other automated equipment. They operate on 90 V.D.C. rectified from 110 V.A.C. Other voltages on special order.

STANDARD FLOATING DISC CLUTCHES AND BRAKES

MAXITORQ offers you PROVED performance in every type of service with the following important advantages: compact design with few and sturdy parts . . . floating neutral with no heating or drag . . . positive engagement or release with light pressure . . . manual assembly and adjustment . . . full range of sizes and types . . . supplied as a completely assembled and easily installed unit.

OVERLOAD RELEASE CLUTCHES

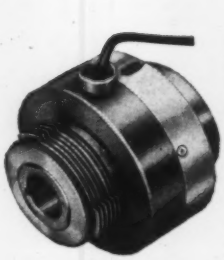
One of the simplest and most efficient methods of providing a DEPENDABLE and easily adjusted overload release feature combined with a clutch. Incorporates all the advantages of MAXITORQ Floating Disc design plus automatic and complete release upon overload. Proved in service. Available in a wide range of sizes.

DISC-PAC

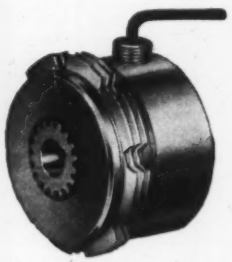
The "heart" of the SERVICE PROVED Maxitorq Floating Disc Clutch in a compact, assembled unit for those who wish to design and build their own clutch mechanisms. Supplied as complete units ready for use in 8 diameters 2" to 8", up to 800 ft. lbs. capacity. Also useful as a multiple disc brake or torque limiting device.

JOHNSON SINGLE DISC CLUTCHES

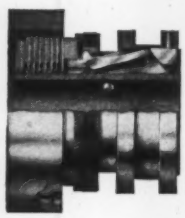
The modern, low cost, dependable clutch for light machinery drives to 6 h.p. Smooth, positive, long service. No matter what your clutch needs, discuss them FIRST with our engineers.



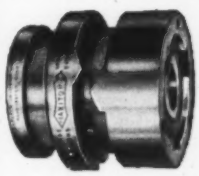
Series 8000 Electric Clutch



Series 9000 Electric Clutch

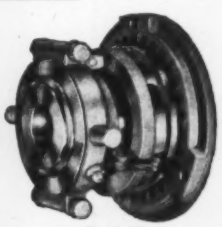


Standard Clutch



Overload Release Clutch

Disc Pac



Single Disc Clutch

Write Dept. MD for details on any of the above products and specify product by title.

LET'S TALK **Maxitorq**

THE CARLYLE JOHNSON MACHINE COMPANY

Manchester, Connecticut

2CJ59

Predetermining Counter

Bulletin AIC-1026 describes the Model CV magnetic predetermining counter. This 3-oz, 6 to 110-v dc, three-digit device is lightweight and compact. 4 pages. Abrams Instrument Corp., 606 Shiawassee St., Lansing, Mich. H

Circle 599 on Page 19

Temperature Control

Model IVA indicating pneumatic temperature control will control heating appliances and give sensitive proportioning valve operation, plus indication at the same time. It is offered in 10 ranges between − 30 and 1100° F. Bulletin 342 describes this control. 4 pages. Partlow Corp., New Hartford, Utica, N. Y. N

Circle 600 on Page 19

Silicones

"Silicones in Missile Design" covers the use of silicones to aid miniaturization and weight reduction in missile components. Brochure is organized for reference to rocket uses for silicone rubbers, resins, dielectrics, fluids, greases, and compounds. 8 pages. Dow Corning Corp., Midland, Mich. H

Circle 601 on Page 19

Utility Pumps

Line of utility pumps featured in Bulletin CP-3489 operates on the helical screw principle. Capacities range up to 50 gpm and pressures to 150 psi. Direct connected and close-coupled motor-driven, engine-driven, V-belt motor-driven, and individual units are described. 8 pages. Continental Pump Co., 1027 S. Vandeventer, St. Louis 10, Mo. I

Circle 602 on Page 19

Universal Coupling

The Tru-Ax universal coupling corrects angular and parallel misalignment of connected shafts. The close coupled, double universal joint coupling is described in booklet along with speed reducers, lathe bed turrets, and combination rotary table and angle plate. 16 pages. Olson Industrial Products, Inc., 40 W. Water St., Wakefield, Mass. B

Circle 603 on Page 19

PVC Piping & Fittings

Both normal and high impact grades of rigid Koroseal polyvinyl chloride piping, fittings, and valves are covered in Catalog 10050-A. It lists specifications and physical properties, and includes data on chemicals safely handled by Koroseal. 6 pages. B. F. Goodrich Industrial Products Co., Marietta, Ohio. F

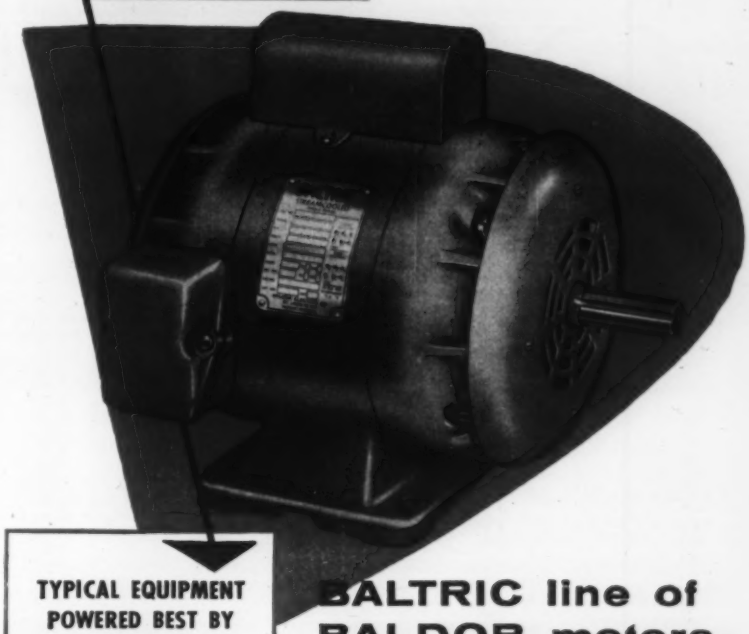
Circle 604 on Page 19

Tiny Mercury Switch

Capable of handling 1-amp resistive load at 30 v ac or dc, the miniature mercury switch described in Data Sheet 149 measures 0.9 in. long by 0.174 in. in diameter. It is particularly suited for instrument, computer, and electronic equipment application. 1 page. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 605 on Page 19

Specially designed with the APPLICATION in mind!



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Conveyors
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Pumps
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No guesswork here! Now you can stop fitting the machine to the motor.

Famous Baldor Streamcooled Motors featuring TEFC construction, are engineered and designed to fit *specific* applications—your guarantee of getting the *one right* motor that will deliver the power and performance to make your equipment operate at top efficiency.

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Circle 475 on Page 19

PUMPS ON YOUR MIND?

Send for this VIKING Pump Data

VIKING ENGINEERING DATA — A 36-page pump engineering manual is yours for the asking. It fully explains the 10 easy steps in selecting Viking rotary pumps. Ask for catalog KH.

VIKING HEAVY DUTY PUMPS — Available in 10 to 1050 G.P.M. sizes, these rugged Vikings are suitable for pressures up to 200 PSI. Complete with specifications, performance data, etc., they are illustrated in the 24-page catalog CH.

VIKING GENERAL PURPOSE PUMPS — These Viking Pumps—in 2/3 to 1050 G.P.M. sizes—are suitable for pressures up to 100 PSI. They are fully illustrated and have specifications, performance data, etc., in the 36-page catalog BH.

All Viking Pumps are positive displacement pumps and deliver either thin or thick liquids.

VIKING—the leader, not a follower, in Rotary Pumps

VIKING PUMP COMPANY
Cedar Falls, Iowa, U.S.A. In Canada, it's "ROTO-KING" pumps

See Our Catalog in Sweet's Product Design File

Circle 476 on Page 19

RUGGED and RELIABLE
New!
TRANSISTORIZED

The A. W. HAYDON COMPANY'S TRANSISTORIZED SUB-MINIATURE ELECTRONIC TIME DELAY RELAYS!

SAVE SPACE AND WEIGHT!

	Miniature Series	Sub-Miniature Series
Cross Section	1 7/16" x 1 21/32"	31/32" x 1 3/16"
Length	2 1/4" long	2" long
Weight	6 ounces	3 ounces
WRITE FOR:	Bulletin AWH TD-503	Bulletin AWH TD-504

TEST-PROVED PERFORMANCE!
High Temperature: 125°C (250°F)
Vibration: 2000 CPS at 15 g
Contact arrangements up to 4 pole double throw.
Unique transistorized R.C. time constant network.
Time Delays from 50 MS to 120 seconds. Longer Delays available.
Hermetically sealed housings.

MEET REQUIREMENTS OF MIL-E-5272A

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249 NORTH ELM STREET, WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices

See us at Booths 2702-2704 at the 1959 IRE Show.

Circle 477 on Page 19

HELPFUL LITERATURE

Fasteners

Names and shapes of more than 70 different fasteners normally specified for aircraft, missile, engine, and related uses are shown in fastener-recognition Bulletin 2460. Front and side view sketches are provided. 4 pages. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 606 on Page 19

Reusable Primary Battery

Outstanding characteristics of the PM Silvercel reusable primary battery are explained in technical bulletin. Battery combines recyclability of the secondary battery, the fast activation of the primary, and high power output of the silver-zinc system. 8 pages. Yardney Electric Corp., 40-50 Leonard St., New York, N. Y. D

Circle 607 on Page 19

Phosphate Coatings

"How to Apply Iron Phosphate Coatings to Steel in Preparation for Painting" explains the advantages of the Cryscoat phosphating process and lists eight reasons why it saves time and money. Procedures and typical uses are covered. 12 pages. Oakite Products, Inc., 19 Rector St., New York 6, N. Y. D

Circle 608 on Page 19

Electronic Equipment

Two illustrated Specification Sheets, 7009 and 7010, are descriptive of a portable 0.05 to 150-v dc electronic voltmeter and a 12-v dc auxiliary power supply, respectively. 2 pages each. Consolidated Electrodynamics Corp., Alectra Div., 325 N. Altadena Dr., Pasadena 15, Calif. L

Circle 609 on Page 19

Hydraulic Piston Pump

Specification Sheets PF-6015 and PF-3021 contain representative performance curves and design details of two hydraulic piston pumps for rated pressures of 6000 and 3000 psi with maximum hydraulic outputs of 50.7 and 43 hp. 2 pages each. Dynex Inc., 777 Dynex Dr., Pewaukee, Wis. K

Circle 610 on Page 19

Precision Nuts

Catalog FS-1000 deals with precision brass and aluminum nuts, including hexagon, closed end cap, open end cap, knurled thumb, lighting fixture, battery, and special types. Full dimensional information is tabulated, and supplementary price lists are offered on aluminum and brass nuts. 20 pages. Fischer Special Mfg. Co., 446 Morgan St., Cincinnati 6, Ohio. G

Circle 611 on Page 19

Fractional HP Motors

Three hundred stock reducer and nonreducer motors are reviewed in Bulletin S-1. Ratings of nonreducer motors listed range from 1/7 to 1/1500 hp. Reducer motors, with speeds from 833 to 0.7 rpm, have torques of 12.8 oz-in. to 219 lb-in. 12 pages. Bodine Electric Co., 2500 W. Bradley Pl., Chicago 18, Ill. J

Circle 612 on Page 19

Milliohmmeter

Specifications for the Model 502 milliohmmeter which will measure resistances down to 30 micro-ohms in production and field tests are given in Engineering Notes Vol. 6, No. 3. 2 pages. Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio. F

Circle 613 on Page 19

Oil, Water & Air Valves

Oil, water, and air valves are covered in individual sections of Catalog 59-60. Over-all pressure range is from vacuum to 10,000 psi. Valves operate on the Shear-Seal principle. 20 pages. Barksdale Valves, Control Valve Div., 5125 Alcoa Ave., Los Angeles 58, Calif. L

Circle 614 on Page 19

Friction & Fluid Drives

Small, medium, and large mechanical clutches; wet type and air-actuated clutches; power take-offs; reduction gears; fluid couplings; torque converters; and marine gears are among the friction and fluid drives detailed in Bulletin 314. Condensed specifications aid in design and application problems. 20 pages. Twin Disc Clutch Co., Racine, Wis. K

Circle 615 on Page 19

Process Pumps

Heavy-duty process pumps in 1 to 4-in. sizes and capacities to 1400 gpm are designed for service up to 300 F and 600 psi. Construction, applications and dimensions are featured in Form 7494. 6 pages. Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y. C

Circle 616 on Page 19

Threaded Specials

Representative special fasteners and parts produced by cold heading, rolled threading, and other cost saving techniques are shown in booklet entitled, "Bring Your 'Special' Problems to National." Data are included on welding fasteners and adjusting or leveling screws, also. 16 pages. National Screw & Mfg. Co., 2440 E. 75th St., Cleveland 4, Ohio. F

Circle 617 on Page 19

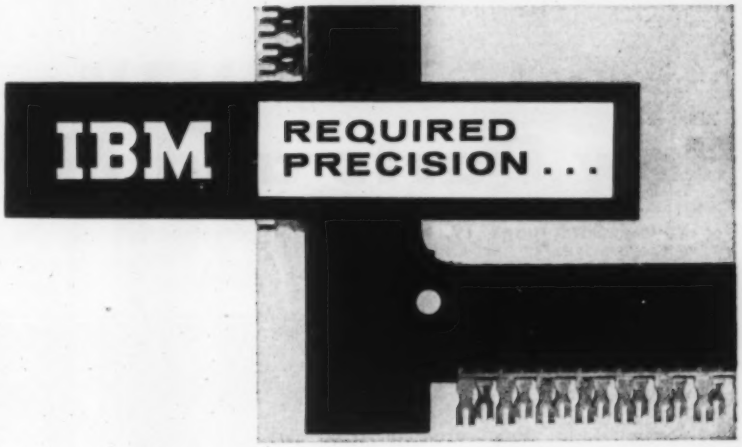
Laminated Panels

Several uses of laminated structural panels are described and illustrated in Booklet 2b/Ha. Building panels with weatherproof faces, Plymetl metal-faced material, Hasko-Preg for die models and patterns, marine panels, and doors are covered. 8 pages. Haskelite Mfg. Corp., 701 Ann St. N.W., Grand Rapids 2, Mich. H

Circle 618 on Page 19

Meehanite Castings

Scope of the applications of Meehanite castings in industry is shown in Bulletin 35. It contains 43 illustrations showing typical applications and gives table of physical properties of types of metals available. 32 pages. Write on company stationary to Meehanite Metal Corp., 714 North Ave., New Rochelle, N. Y. D

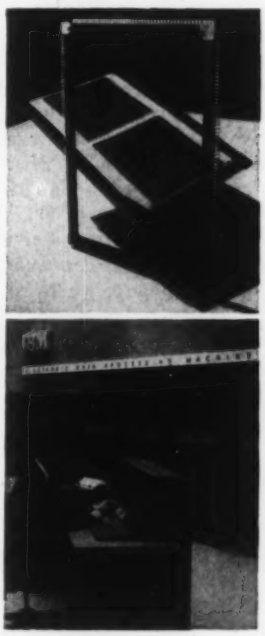


and got it from
CONSOLIDATED

This 12" x 15" phenolic "Memory Frame" for IBM was plunger molded in one piece with 440 wire terminal inserts. Later, strung with copper wire containing a series of 8,000 ferrite magnetic cores, these frames are stacked one atop the other and wired together in conjunction with other components to give IBM's 705 Data Processing System a "memory" capacity of 40,000 characters.

Dimensionally stable frames that would withstand dip soldering at extra high temperatures were a necessity. They could not bow or crack, nor could there be more than minimum after-shrinkage or expansion once assembly was completed.

For more than 80 years we have been filling exacting plastics orders for the nation's blue chip companies. Before you discard any design you feel can't be molded in a plastic, call Consolidated.



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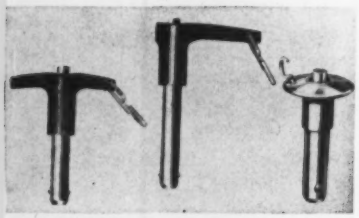
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Quick-Release Pins

self-locking units have new handles

Single-acting Pip Pins are for aircraft and missiles, ground-support equipment, electronic components, and general-industry applications. New handle design makes self-locking pins easier to grasp, easier to insert and remove, and permits better hold with knurled underside of handle. Valley around larger release button provides additional thumb space for easier operation. Pushing release button moves spindle to permit steel balls



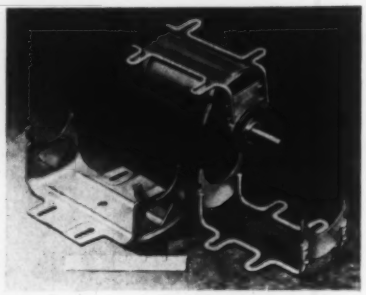
to recede flush with outer surface of pin body, for faster insertion or removal. New T and L-type handle styles and button-head type are available in diameters to fit nominal holes from 3/16 through 1 in. **Aviation Developments Inc.**, 210 S. Victory Blvd., Burbank, Calif. L

Circle 619 on Page 19

Wire Motor Mount

for fractional-horsepower units

Twin-arm motor mount permits reductions in shaft height of 1/4 in. or more over stamping-type mount by allowing base of fractional-horsepower motor frame to nest between two parallel base wires. The lightweight mount is particularly suited to air-conditioning units and portable appliances, where over-all compactness is necessary. Natural resiliency and vibration-dampening characteristics of wire construction



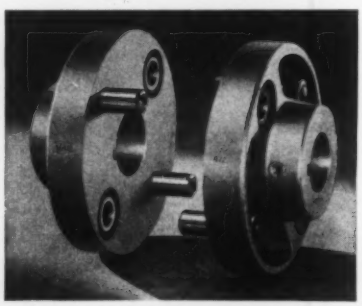
in mount permit improved decibel ratings. Open configuration allows unrestricted air circulation and reduces air turbulence. Mount meets NEMA specifications, and supports motor vertically or horizontally. Dimensions, wire gage, and bolt pattern can be modified to meet individual specifications. **E. H. Titchener & Co.**, 67 Clinton St., Binghamton, N. Y. N

Circle 620 on Page 19

Flexible Couplings

for use on direct-driven machinery

Series 400 couplings utilize steel studs and rubber-cushioned sleeve bearings to provide positive, resilient drive. Units are for use on direct-driven machinery where torque is not excessive in relation to shaft diameter, such as in pumps, fans, ventilators, mixers, speed reducers, light-duty hoists, compressors, and other machinery where shafts are



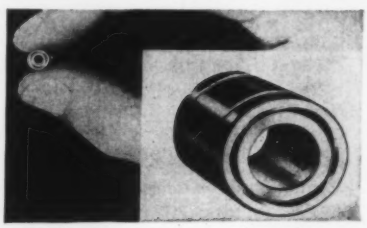
oversize in relation to torque in order to secure sufficient bearing size. Couplings are available with 1 1/4, 1 3/4, 2 1/4, and 2 3/4-in. maximum bore with standard square keys. **Ajax Flexible Coupling Co. Inc.**, Westfield, N. Y. N

Circle 621 on Page 19

Miniature Ball Bushings

for shaft diameters of 0.1246 and 0.1871 in.

INST-258 and 396 linear ball bushings are for use in critical instruments and accessories in missiles and aircraft. Weighing only 0.15 and 0.30 oz, they are for shaft diameters of 0.1246 and 0.1871 in. Each bearing contains three complete ball circuits, with each circuit containing sixteen balls in the



smaller and seventeen balls in the larger bushing. Bushings withstand high vibrational and shock loads, and have minimum static and rolling friction. **Thomson Industries Inc.**, Manhasset, L. I., N. Y. D

Circle 622 on Page 19

Vibration Pickup

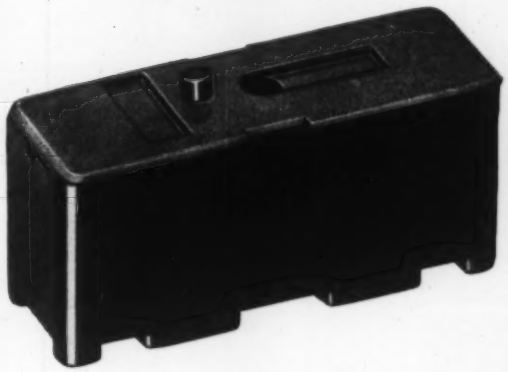
miniature unit is eddy-current damped

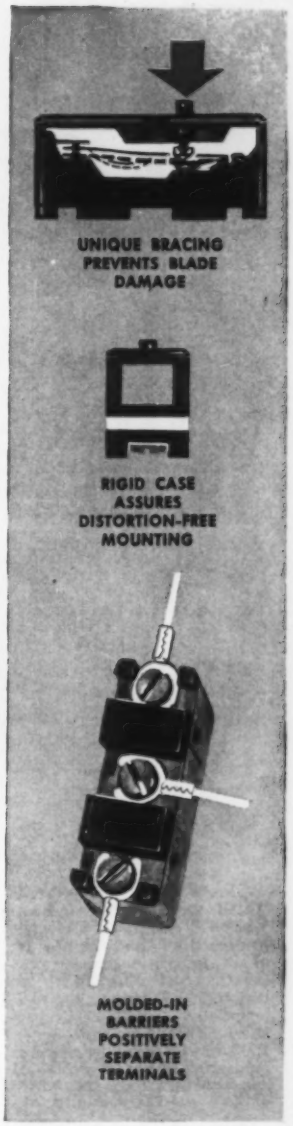
Type 11 Vibramite has self-generation with no cathode follower or other impedance matching amplifier required, and good temperature stability with high electrical output. It is an eddy-current-damped unit with flat response curve over full operating range. Acceleration

PIN PLUNGER - type S2A6A1
LEAF-SPRING - type S2A6B1
ROLLER LEAF - type S2A6C1
HINGED RIGID LEVER - type S2A6D1
LONG HINGED ROLLER LEVER - type S2A6E1
SHORT HINGED ROLLER LEVER - type S2A6F1
STUB PLUNGER - type S2A6G1
PANEL-MOUNT PLUNGER - type S2A6H1

NEW HiPAC PRECISION SWITCHES

Series S2A




UNIQUE BRACING PREVENTS BLADE DAMAGE
RIGID CASE ASSURES DISTORTION-FREE MOUNTING
MOLDED-IN BARRIERS POSITIVELY SEPARATE TERMINALS

take on *high current* in control and indicating circuits

Hetherington's new HiPAC Precision Switches represent the latest refinements of the switchmakers' art. Compact and precision made in every detail, these small high-current switches provide carefully controlled force and movement characteristics for unsurpassed repeatability in critical applications. One-piece blade actuators of selected beryllium copper operate against solid silver contacts to give long, stable mechanical and electrical life with uniformly low contact resistance.

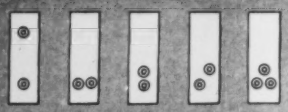
Here's a capsule run-down on the new Series S2A Switches: rated at 20 amps., 125/250 volts ac, 1 and 2 horsepower ac; U.L. Inspected; SP-DT circuit; unusually rigid ammonia-free phenolic case; interchangeable with other precision switches of equivalent ratings; built-in safety limit to prevent over-travel damage to blade; molded-in barriers to provide long creepage paths and positive separation between terminals and leads.

HiPAC Precision Switches are available with any of eight actuators. Prompt delivery of samples may be obtained from over 50 leading electronic parts distributors — use part numbers shown above to order. For complete specifications, write for Hetherington Bulletin S-9.

HETHERINGTON INC. • Folcroft • Pa. • A CONTROLS COMPANY OF AMERICA SUBSIDIARY

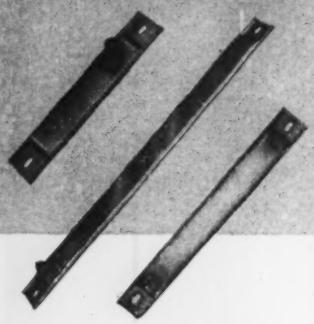
SEE US AT THE IRE SHOW BOOTH 3805

Choice of Terminal Arrangements



for

VULCAN STRIP HEATERS



The terminal arrangements illustrated are just one indication of *Vulcan Versatility* in electric strip heaters. You also have a wide choice of standard seamless one-piece sheaths — steel for sheath temperature to 750°F, chromalloy to 1200°F; lengths 8" to 42½" (special — shorter or longer); wattage — 150 to 1500 watts (or higher); rugged non-oxidizing terminal posts. Heaters can also be formed into circles (one or two piece) in radius of 5" or more.

Vulcan Electric Strip Heaters are ideal for contact heating of dies, platens, molds, or any item with flat surfaces to which elements may be clamped; also as air heating sources for ovens, air ducts, dryers, etc.

Solve your hot problems with *Vulcan Versatility* in the application of electric heat. Send coupon for catalog and prices.

VULCAN ELECTRIC COMPANY
Danvers, Mass.

VULCAN ELECTRIC COMPANY
6 Holten Street, Danvers, Mass.

Please send me catalog and price information on Vulcan Electric Heaters.

Name & Title.....
Company.....
Street & No.....
City & State.....

Circle 479 on Page 19

to 50 g for continuous duty and to 100 g intermittently does not damage unit. In shock tests, pick-up operated perfectly under impact shocks to 100 g in all directions. Size is 1.42 in. square and 1 in. high, with weight of 2.75 oz. Unit operates at continuous tempera-

tures of −85 to 500 F with minimal effect on sensitivity. **MB Mfg. Co.**, P. O. Box 1825, New Haven 8, Conn. B

Circle 623 on Page 19

Epoxy Resin

provides good resistance to thermal and mechanical shock

Hysol 6621 is a flexible epoxy resin system with wide range of possible cures. It has been successfully used for potting transistorized circuits and transformers with strain-sensitive cores. Resin can also be adapted to the casting of large masses where exotherms cannot be tolerated and where rapid production is necessary. Providing excellent resistance to thermal and mechanical shock, castings of the resin containing large steel inserts of various configurations have been cycled between −65 and 150 C with no cracking. **Houghton Laboratories Inc.**, Houghton Avenue, Olean, N. Y. N

Circle 624 on Page 19

Nylon Cable Clips

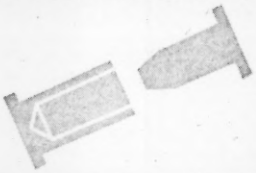
have ribbed reinforcing edge

Molded-type nylon clips which apply quickly, easily, and firmly, are available in black or natural color. Ribbed reinforcing edge adds strength for holding firmly and indefinitely against vibration, weather,

AUTOMATIC ASSEMBLY

IS FAST,

ECONOMICAL,



TROUBLE-FREE

with Milford tubular rivets and automatic riveters

Mass production and automatic assembly cut costs only when all operations are trouble-free. That's why the high strength and uniform quality of Milford Tubular Rivets, plus Milford's wide line of precision riveters, are playing an active role in slashing today's production costs.

For the answers to assembly problems... *get in touch with Milford first!*

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNA.
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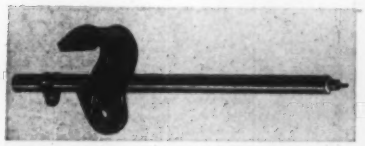
Circle 480 on Page 19



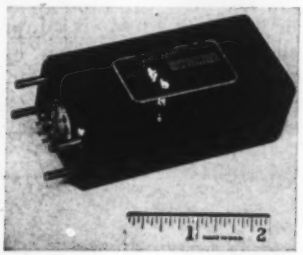
moisture, and chemical corrosion. Clips are nonconductive and have no sharp edges to endanger insulation or tubing. Commercial Plastics Co., 945 George St., Chicago 14, Ill. J

Circle 625 on Page 19

Miniature Servo Amplifier

transistorized unit delivers up to 13 w continuous power

Model 1800-0300-4 is a hermetically sealed, miniaturized, seven-pin, plug-in transistor servo amplifier primarily designed for use with a motor load such as a servo or synchronous motor. It delivers up to 13 w of power continuously. Input signal can be from such sources as a synchro control transformer, tuning-fork oscillator, or signal from an



electrical bridge. Unit operates in temperatures from −55 to 71 C. Dimensions are 1 3/16 x 1 11/16 x 3 13/16 in. M. Ten Bosch Inc., 80 Wheeler St., Pleasantville, N. Y. D

Circle 626 on Page 19

Check Valve

for gas and liquid service to 10,000 psi

Heavy-duty valve is applicable for high-flow, heavy-surge applications. It is designed for high-pressure gas and liquid service to 10,000 psi. All metal parts are stainless steel, and seals are Teflon or synthetic rubber. Valve is made for connections with Bureau of Standards high-pressure tubing and fittings in sizes 1/4, 3/8, 9/16, and 1 in. at design pressure. It is also available with 1/4 and 1-in. flared and flareless tube connections,

COMPLETE LINE OF
ACME ROLLER CHAINS
and ACCESSORIES
Available at YOUR LOCAL
INDUSTRIAL DISTRIBUTOR

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It is the basic policy of Acme Chain to sell its product through *Authorized* Distributors who have entered an agreement with the company to stock merchandise and service all Acme Products.

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Acme supports their Distributors with all the knowledge and assistance of their Engineering Department in an advisory and technical capacity.

Order Acme Chain from your Industrial Distributor with implicit confidence that you will receive prompt and efficient service at all times.

Write Dept. 6-V for new 100-page illustrated catalog, including new engineering section showing 36 methods of chain adjustments.

Call ACME for Service

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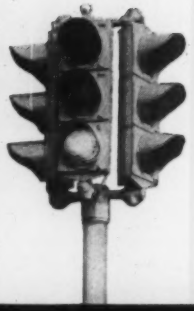
HOLYOKE MASSACHUSETTS

COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

Circle 481 on Page 19

Neither dust, dirt, moisture nor temperature changes can affect an Adlake relay. Hermetically sealed mercury-to-mercury contact is quiet, chatterless . . . can't burn, pit or stick. A-plus qualities backed by a century of service. What's your control problem? Write today. No obligation.

a lot at stake?



NO. 1140, one of 4 basic models designed to your control needs.

depend on A+ Adlake mercury relays and controls

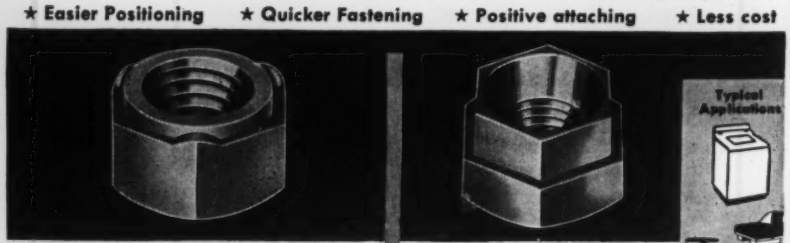
SEND FOR FREE CATALOG J-8903
Adams & Westlake
Elkhart, Indiana

Circle 482 on Page 19

Use These GRIPCO NUTS

FOR "FIXED" and "BLIND" fastening to get

★ Easier Positioning ★ Quicker Fastening ★ Positive attaching ★ Less cost



GRIPCO PILOT-PROJECTION WELD NUT

The centering pilot provides quick, easy positioning of nut in pre-punched hole for instant resistance welding. No jigs, no fumbling, no waste of time. No fouling of threads. In two pilot and projection heights with or without the Gripco Locking feature. Sizes No. 6 thru 5/8".

GRIPCO COUNTERSUNK WELD NUT

Countersunk feature eliminates time-wasting re-tapping of nut after welding. The 3 weld projections on both type nuts provide a firm non-rocking electrical connection.

GRIPCO CLINCH NUTS

With or without Gripco locking feature, for positive attaching of a threaded medium to thin metals. Can be automatically fed and clinched or staked with hydraulic or air equipment.

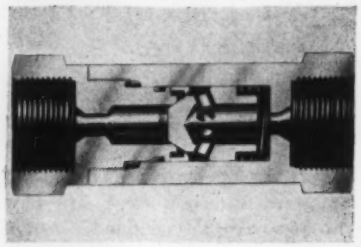
Write for this new FREE catalog today. Ask for samples.

ALL GRIPCO FASTENERS AVAILABLE FOR IMMEDIATE DELIVERY

GRIP NUT COMPANY
103 Maple Ave. • South Whitley, Ind.

Ad No. 122

Circle 483 on Page 19



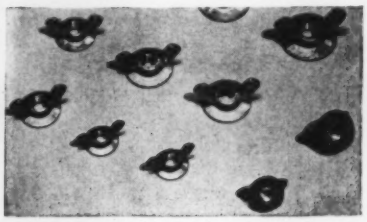
and 1/8 to 1-in. pipe, for services to 10,000 psi depending upon strength of tube and fittings. Temperature range depends upon composition of seat and seal. **Republic Mfg. Co.**, 15655 Brookpark Rd., Cleveland 35, Ohio. G

Circle 627 on Page 19

Washer Wing Nuts

in sizes from 1/2 to 7/8 in. diam

Washer-base wing nuts are zinc alloy, and can be plated in brass, gilt, bright nickel, or oxidized finishes if decorative consideration is important. Sizes range from 1/2 to 7/8 in. diam with thread sizes from No. 6-32 to 3/8-16. Integral washer of nuts provides a broad bearing base so that they can be used with soft structural materials. Washer covers large or off-center



holes to give a finished appearance. Added bearing surface is also helpful where adjustable assemblies require wide slots for bolt. **Gries Reproducer Corp.**, 125 Beechwood Ave., New Rochelle, N. Y. D

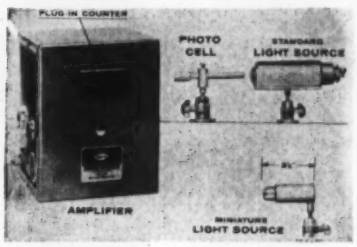
Circle 628 on Page 19

Photoelectronic Counter

incorporates six-digit, plug-in counting element

Robot-Eye RE-8 industrial counter operates at speeds over 1500 counts per minute by interrupted or reflected light beam. There is no physical contact with objects being counted. Unit embodies a six-digit

plug-in counter which has a long life. Replacement counter element plugs in, extending instrument life indefinitely. Touch of a button resets counter to zero. Counter consists of amplifier-counter, photocell, and light source. Photocell and light source are swivel mounted for easy installation and alignment. Standard light source is only 5 in. long; miniature light source, also available, is only 2¼ in. long. Sensitivity adjustment is provided in



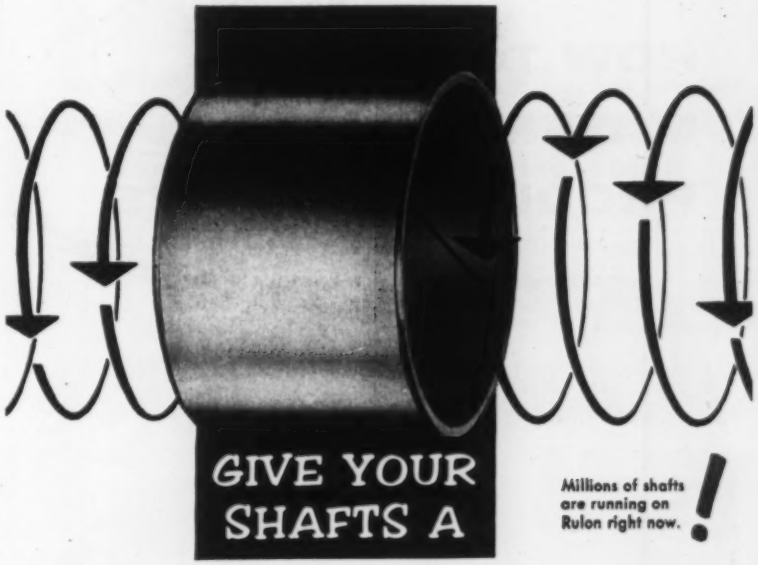
amplifier. Power supply is 115 v, 60 cycles ac, with other voltages available. **Standard Instrument Corp.**, 657 Broadway, New York, N. Y. D

Circle 629 on Page 19

Component Socket

for printed-circuit boards

Dual-entry Vari-Grip socket has crimped snap-lock, feed-through design that eliminates solder installations for testing expensive components. Finished in gold-flashed copper alloy, socket is easily crimped in place for positive high-speed assembly by automatic equipment or bench or hand tools. Beryllium-copper spring band is used to snap-lock wire after insertion during circuit-board build-up. Designed to solve printed-circuit board problems involving plug-in components such as diodes, transistors, subminiature vacuum tubes, capacitors, resistors,



FREE RIDE

on this low cost antifriction bearing

Dixon's T-Liner Sleeve Bearings . . . with antifriction "floating" Rulon® insert (modified TFE Teflon†) . . . are ready-built for installation in your designs. Available off the shelf in ten standard sizes, T-Liners give free riding, low friction performance on rotary or linear moving shafts.

These new bearings are recommended for PV values up to 10,000 *without lubrication!* (PV is the product of load on bearing in psi times rubbing speed in feet per min.) A thin Rulon insert within the metal shell . . . having extremely low coefficient of friction and 12 times the wear resistance of nylon . . . automatically adjusts itself to compensate for temperature changes. Unlike most plastics, Rulon is unaffected by moisture. Frictional heat is quickly dissipated through the liner and shell. Because of compactness and wide temperature adaptability (from sub-zero to 500°F), T-Liners answer many difficult space and environmental design conditions.

Besides eliminating lubrication, these bearings overcome problems of dirt, noise, and corrosion. They're lightweight, easy to install, and virtually maintenance-proof.

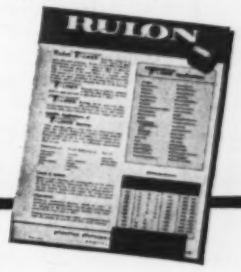
If your product incorporates rotating, reciprocating, or oscillating shafts, it will pay you to investigate Dixon T-Liners.

Standard Rulon T-Liner Bearings			
No.	ID in.	OD in.	Length in.
5201	¼	11/32	⅜
5202	3/16	⅜	3/16
5203	⅜	½	½
5204	½	⅝	½
5205	⅝	¾	¾
5206	¾	⅞	¾
5207	⅞	1	¾
5208	1	1⅛	1
5209	1⅛	1¼	1
5210	1¼	1⅜	1

†Du Pont TM

Engineering Data Sheet 32-T gives complete details. Write for your copy today.

DIXON CORPORATION
Bristol, Rhode Island

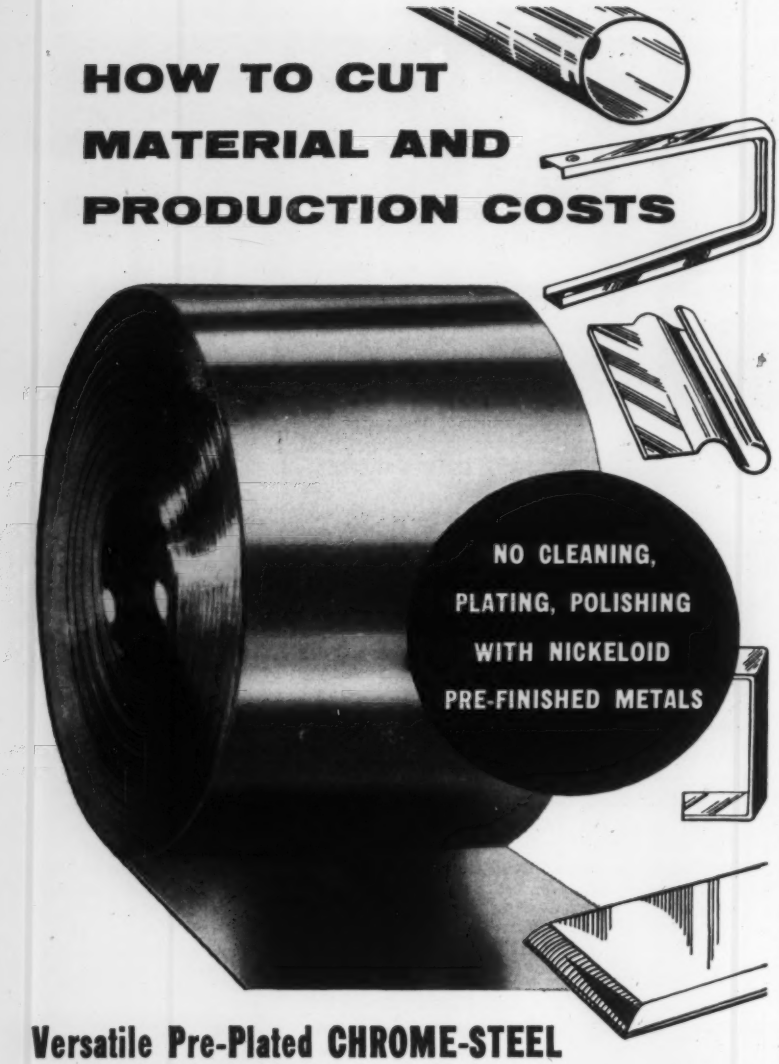


Dixon

suppliers of basic shapes and fabricated parts in Rulon and Teflon.

Circle 484 on Page 19

HOW TO CUT MATERIAL AND PRODUCTION COSTS



Versatile Pre-Plated CHROME-STEEL and NICKEL-STEEL Now Available in Three Grades

Cut costs! — Reduce production steps! The *need* was never greater; the *method* never surer than with Nickeloid chrome-steel and nickel-steel . . . now available in C-grade, *a new low-cost utility grade* for applications that don't require the quality of our A and B grades. These cost-cutting design materials are *pre-finished* — eliminate extra handling, cleaning, racking and polishing costs, plus actual plating costs. So versatile — adaptable to standard production methods, too! Their beautiful durable finishes can add so much in sales and utility value to your products at very low cost. Cut costs, reduce production steps with Nickeloid chrome-steel or nickel-steel — big 24" wide coils, sheets, strips; bright and satin finishes. Now save even more with new low-cost C-grade!

NICKELOID METALS SINCE 1898 N·M

Write For More Information

AMERICAN NICKELOID COMPANY

PERU 8, ILLINOIS

MILLS — Peru, Illinois and Walnutport, Pennsylvania **Sales Offices Throughout the U.S.A.**

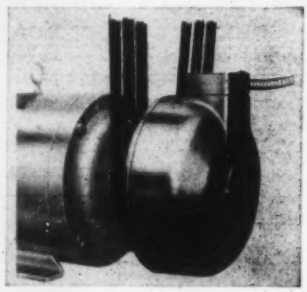
and computer applications where soldering is not desired, socket affords maximum heat sink. Socket is available for circuit boards measuring ⅛ to 1/64 in. thick. **Grinnell-Harris Electronics Inc.**, 4130 Temple City Blvd., Rosemead, Calif. L

Circle 630 on Page 19

Clutch-Sheave Combination

electromagnetic unit is shaft mounted

Cyclesheave is readily installed on electric-motor or other existing shaft extensions, and is a complete package including protective shroud, sheaves, and clutching unit with complete internal electrical connections. The shaft-mounted combination is available for drive requirements from ½ to 50 hp and with



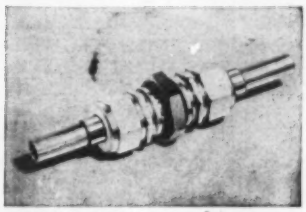
sheave diameters and belt grooves to meet majority of standard drive requirements. Only external connections required are low-current lead wires to clutch. **Cycledynamics Inc.**, 19025 W. Davison Ave., Detroit 23, Mich. H

Circle 631 on Page 19

Coupling Nut

for hydraulic lines is self-locking

Series CN-8 nut insures vibration-proof tightness in critical fuel, oil, and refrigerant lines subject to vibration. The one-piece, self-locking unit is adaptable to either flared or flareless methods of tube sealing, resisting loosening under severe vibration even when not fully seated. Unaffected by oils, the stainless-steel nuts are usable to 800-F working temperatures and steel nuts to 550 F. Nuts are reusable more than 15 times without impairment of locking properties. Applications include use in



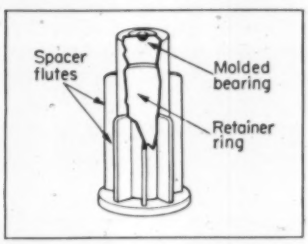
aircraft and missiles, machine tools, automotive and diesel engines, and air conditioning and refrigeration. Fasteners meet locking-torque requirements of specification MIL-N-25027. Nine sizes range from 1/4 to 1 1/2 in. diam. **Standard Pressed Steel Co.**, Jenkintown, Pa. C

Circle 632 on Page 19

Caster Sockets

incorporate molded nylon bearing

Mobilon sockets provide ball-bearing mobility with use of plain pivot-bearing casters. They contain a molded nylon bearing against which caster stem swivels. Without metal-to-metal contact, squeaks, rusting, and need for lubrication are automatically eliminated. Sockets also act as cushions to absorb shocks and vibration for quieter movement. Units are finished for every type of caster stem or leg of metal or wood. Molded-in retainer rings holds grip-



neck caster stems in place. Plain sockets are available for spring-ring stems. **Harvard Mfg. Co.**, 7619 Grand Ave., Cleveland 4, Ohio. F

Circle 633 on Page 19

Reversible Motor

is rated 1/125 hp for continuous duty

M-105 small-size, lightweight universal motor is available in several models, ranging from 6 to 48 v dc input. It is rated 1/75 hp in intermittent duty or 1/125 hp continu-

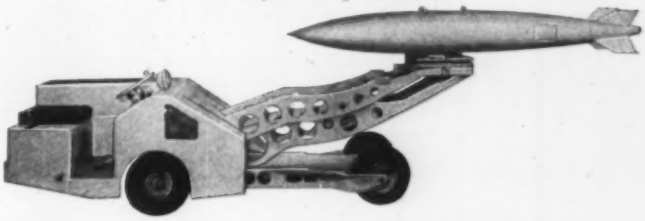
a NICAD TRADEMARK battery

...PACKAGED PAYLOAD of RELIABLE POWER at -40°

for Standard Manufacturing's MJ-1

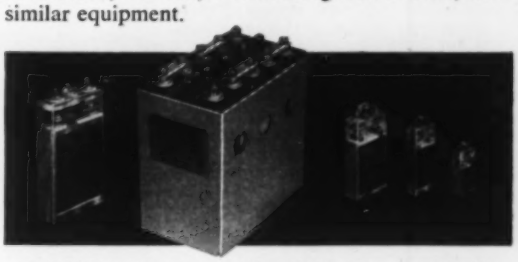
Capable of completely dependable operation at –40°F.

an exceptionally rigorous performance demand met by Standard's MJ-1 and its components—of which the NICAD nickel cadmium battery is a vital one. Standard uses a 6 volt NICAD sintered plate battery as the engine starting power source on these bomb lifts . . . and avoids engine starting failure which would detract from the service and dependability of its products.



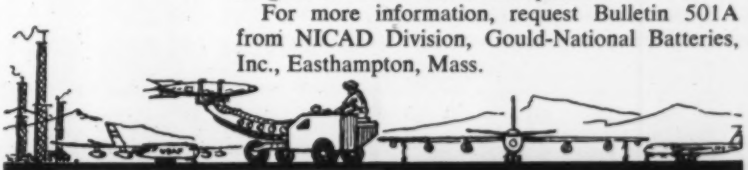
NICAD batteries will not freeze in any state of charge, and perform at peak efficiency in temperatures below the –40° requirement here, and as high as 140°.

Also produced in smaller sizes that make sense to designers, NICAD sintered plate batteries possess power output and other advantages that make them especially adaptable to the confined systems of missiles, aircraft, telemetering instruments, and similar equipment.



NICAD offers cycle life which far exceeds that of any other type battery . . . peak operational efficiency under severe conditions . . . low internal resistance that creates high discharge rates . . . capacity range from ½ to over 150 ampere hours.

For more information, request Bulletin 501A from NICAD Division, Gould-National Batteries, Inc., Easthampton, Mass.



NICAD TRADEMARK

NICKEL CADMIUM ALKALINE STORAGE BATTERIES

Circle 486 on Page 19

O-M Heavy-Duty Series TH Hydraulic (Oil) Cylinders

IF you are experiencing difficulty with leakage through the seals and packings of the cylinders you have been using, the O-M "TH" Series Heavy Duty Hydraulic cylinders may be the answer to your problem. Since their introduction in 1955 these cylinders have established an enviable reputation for efficient and trouble-free service.

The O-M Series TH Cylinders are Designed Right to Seal Right. Prior to the design of these cylinders, many tests were made and field experiences were surveyed to find the most efficient way to eliminate the old "leakage problem".

Homogeneous "O" rings, with their elastic characteristics, cannot be excelled as static seals when backed-up with plasticized leather non-extrusion rings and installed in a properly designed cavity.

Ring-type piston packings are excellent for long-life and trouble-free performance when a small amount of piston by-pass is permissible. When by-pass is not allowable, "Vee-type" packings similar to those used as standard in the rod gland provide optimum sealing. The "Vee-type" packing is self adjusting and provides multiple lip sealing with excellent pressure sensitivity and long life.

The homogeneous "lip-type" rod wiper or the metallic scraper (your choice) is located well forward so as to prevent dirt from accumulating and scoring the piston rod and damaging the bearing and packing.

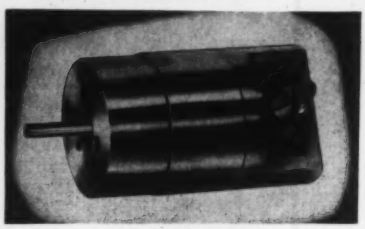
O-M Series TH Cylinders are "Designed Right" and "Sealed Right". Available in 1¼" to 8" bores with complete selection of mountings. Mail coupon TODAY for Bulletin No. 105 showing description drawings of cylinders mountings and capacity chart.

ORTMAN-MILLER MACHINE CO.
7 143rd Street, Hammond, Ind.

☐ Have representative call
☐ Send Bulletin 105

Name_____ Position_____
Company_____
Address_____
City_____ Zone____ State_____

Circle 487 on Page 19



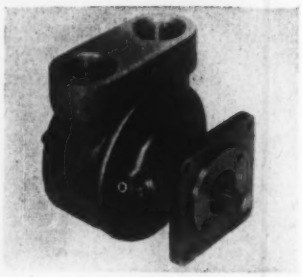
ous duty. Variety of baked-enamel color finishes is available, as well as polished aluminum from which motor body is made. A streamlined end cap is available. Weight is under 10 oz. Unit is approximately 1¾ in. in diam by 3 in. long, plus ¾ to 1-in. shaft extension. **Carter Motor Co.**, 2719A W. George St., Chicago 18, Ill. I

Circle 634 on Page 19

Rotary Pump

for a variety of applications

Model CBGFK pump meets Air Force-Navy Aeronautical design standards for use on ground equipment. It is provided with a splined shaft, mounting pad, and porting to meet AN-D specifications. Pump is available in two sizes, with capacities from 10 to 45 gpm at 150 psi



and for speeds to 3600 rpm. It can be adapted to a variety of applications. **Tuthill Pump Co.**, 953 E. 95th St., Chicago, Ill. J

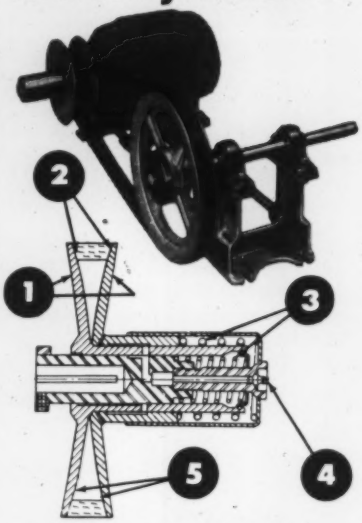
Circle 635 on Page 19

Tubes and Coil Forms

of inorganic bonded muscovite-mica paper

Pyratherm spiral-wound tubes and coil forms remain physically stable and without loss of insulation value at temperatures to 1100 F. The low-cost units have 80 v per mil electrical strength and 3.4 × 10^9 volume resistivity after 1000 hr.

feature by feature...



INDUSTRY'S MOST EFFICIENT VARIABLE SPEED PULLEY

1. Both sides of the driving disk open simultaneously and equally to give constant belt alignment.
2. Power is transmitted through sides of the belt to a grooved sheave to insure maximum efficiency and prevent slippage.
3. Each side of the driving disk is independently actuated by its own spring, eliminating rachets, cogs, gears or other moving parts subject to constant maintenance and wear.
4. Oilite bronze bushings on fractional hp. units provide life-time lubrication.
5. Curved pulley faces maintain full contact with belt sides at all times, greatly increasing overall efficiency.

Pulleys are available in a complete range of sizes, fractional to 15 hp.—full 3 to 1 ratio. Immediate delivery from stock.

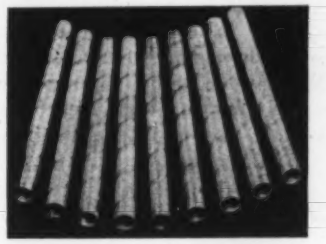
Request recommendations for your application. Ask for Catalog P-58.

Lovejoy — FIRST NAME IN VARIABLE SPEED PULLEYS

LOVEJOY FLEXIBLE COUPLING CO.
4818 West Lake Street, Chicago 44, Illinois
Telephone: EStebrook 9-3010

Circle 488 on Page 19

Stability of tubes makes it unnecessary to compensate in mandrel size for shrinkage or explansion. They resist heat and cold shock and are unaffected by ordinary neutral lubricants or organic solvents. Applications include: Coil cores for solenoids; motor stud insulators; heater-element bushings; square and rectangular cores for Class H or C transformers; resistors and grid rheostats; electronic tube supports; tubes for high-frequency apparatus; heating elements or spacers. Tubes are available in round, square, or rec-



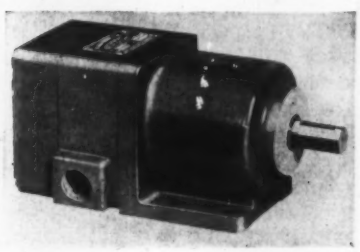
tangular shape. Lengths range from 1/16 to 48 in.; OD's from ⅛ to 6 in., and wall thicknesses from 0.004 to 0.06 in. **Resinite Corp., Div., Precision Paper Tube Co.,** Dept. MDC, 2035 W. Charleston St., Chicago 44, Ill. I

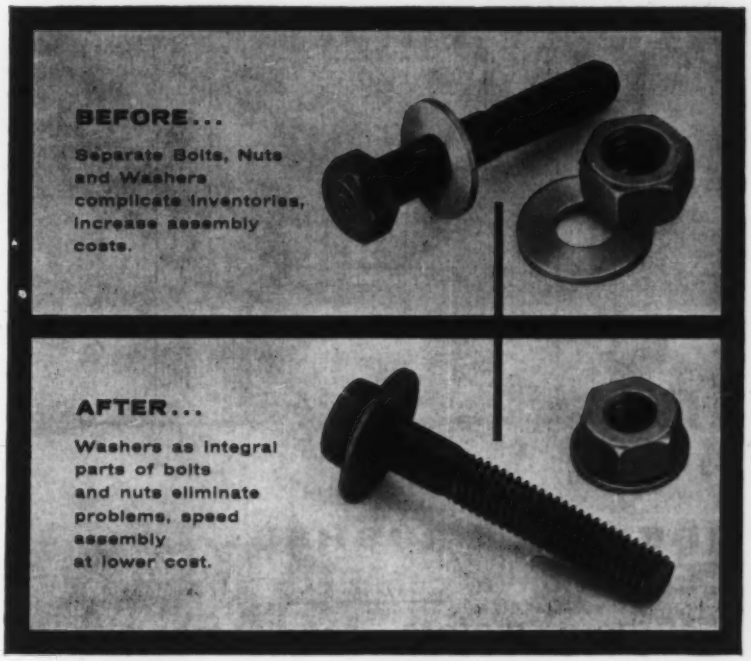
Circle 636 on Page 19

Centrifugal Switch

has adjustable speeds from 70 to 5000 rpm

Measuring 7¾ in. long x 3-9/16 in. high x 3¾ in. wide, type C centrifugal switch has an over-all adjustable speed range from 70 to 5000 rpm. Operating speed is adjustable while switch is running. Unit is housed in an enclosure molded of glass-fiber reinforced polyester resin. Switch withstands severe shock impacts, is resistant to acid, alkali, salt compounds, and moist corrosive atmospheres. Two separate sets of contacts can be adjusted for operation at different




BEFORE...
Separate Bolts, Nuts and Washers complicate inventories, increase assembly costs.
AFTER...
Washers as integral parts of bolts and nuts eliminate problems, speed assembly at lower cost.

Save Money

by simplifying fastener design

Here is a simple application of a basic bolt making principle which is affecting substantial savings for a number of manufacturers.

These savings, resulting from simplified design, are realized in every step of the operation from lower first cost of the fasteners through inventory to final assembly. Totalled, they are well worth while.

There are many other basic principles . . . often overlooked in designing and specifying fasteners, which are of importance cost-wise.

You'll find them in our new booklet, "How to specify fasteners . . . and save". Filled with drawings and charts, it makes a handy guide in designing or buying any headed parts.

If you can use a copy, write to North Tonawanda or ask a Field Representative.

BUFFALO BOLT COMPANY

Division of Buffalo-Eclipse Corporation

North Tonawanda, N. Y. • Princeton, Illinois

MAKING BOTH FASTENERS AND FRIENDS FOR 100 YEARS

● *3 convenient service centers*

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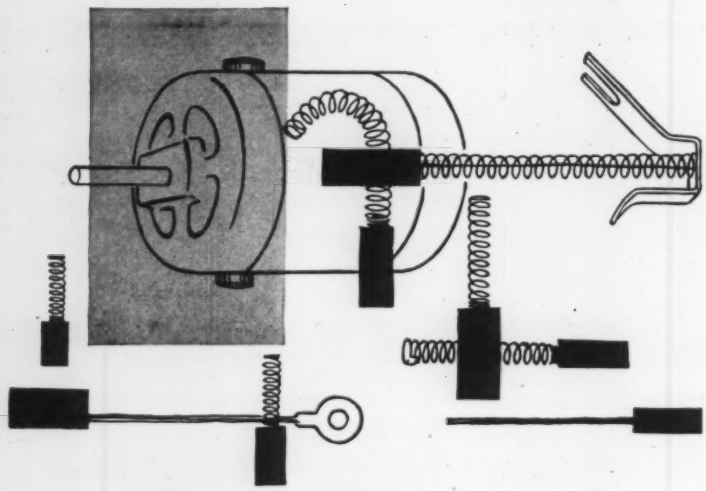
Chicago	New York City	North Tonawanda
HArrison 7-2178	REctor 2-1888	JAckson 2400 (Buffalo)

Circle 489 on Page 19



BETTER BRUSHES...
based on a complete analysis of your motors' requirements

Stackpole Custom Brush Engineering solves as many brush problems by detailed attention to such mechanical factors as shunts, springs, terminals or caps, tolerances, corner bevels and heads as it does by recommending suitable brush grades. More to the point, modern brush selection for motors of all sizes is based on a combination of the two—and Stackpole supplies this combination in full measure.

Most of our recommendations are based on extensive tests of the actual motorized equipment in the Stackpole laboratories. Specific motor operating conditions and specified performance objectives are fully considered. Variables taken into account include rpm., service load, desired brush life, permissible commutator wear, acceptable noise levels, contaminating atmospheric influences, temperature rise and others. Brush grade and brush mechanical factor recommendations are then made accordingly.

This service costs nothing extra and goes far toward assuring maximum dependability for your motors.

Stackpole brushes are sold only as original equipment—not as replacements.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

BRUSHES • CONTACTS • VOLTAGE REGULATOR DISCS • CATHODIC PROTECTION ANODES • SEAL RINGS • CLUTCH RINGS • FRICTION SEGMENTS CHEMICAL ANODES • POROUS CARBON and dozens of other related products.

STACKPOLE
Custom-Engineered
BRUSHES
for all rotating electrical equipment

Circle 490 on Page 19

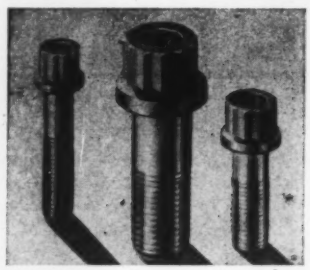
speeds so that two operations can be controlled from one speed-sensitive switch. It is therefore possible to perform two different functions at two different speeds. Euclid Electric & Mfg. Co., 54 Edwards St., Madison, Ohio. F

Circle 637 on Page 19

High-Temperature Bolts

for use to 1600 F

Available in both airframe and engine-bolt configurations, standard structural fasteners are fabricated from M-252, Waspalloy, Udimet 500, and Hastelloy R-235. They are for use at temperatures to 1600 F. Developed primarily for aircraft, jet-engine, missile, and rocket use, fasteners can also be used in gas



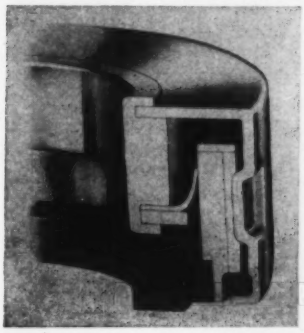
and steam turbines and related units. Minimum tensile strength of bolts is 155,000 psi at room temperature, 135,000 psi at 1200 F, and 85,000 psi at 1600 F. Bolts are external-wrenching type with 12-point configuration. Sizes range from No. 6 through 1½ in. diam. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 638 on Page 19

Metal Shaft Seal

seals at temperatures from −65 to 850 F

Components of Met-L-Seal, except seal face, are high-temperature alloy steels. Face materials are carbon graphite or various exotic alloys. The all-metal unit functions at temperatures from −65 to 850 F and higher. Construction permits no internal fatigue and gives positive guarantee against sudden complete operational failure in extreme operating conditions. Seal fits into minimum space required by aircraft-missile applications. Hydraulic balance produces



optimum sealing under both static and dynamic conditions. **Gits Bros. Mfg. Co.**, 1866 S. Kilbourn Ave., Chicago 23, Ill. I

Circle 639 on Page 19

Epoxy Resin

resists temperatures to 500 F

Maraset epoxy resin system is for casting, laminating, and adhesive uses where high heat resistance is required. The multifunctional liquid resin is available in Type 617-A, aluminum filled, and Type 617-C, clear. Both have low viscosity, which can be maintained at room temperature for as long as 30 min after mixture with hardener. In both filled and clear forms, resin resists operating temperatures to 500 F, with heat-distortion point of 425 F. At higher temperatures it retains elasticity rather than exhibiting a tendency to break. Maximum deformation is 0.01 in. per in., and is partially recoverable. High strength at elevated temperatures is another characteristic of the resins. **Marblette Corp.**, 37-31 Thirtieth St., Long Island City 1, N. Y. D

Circle 640 on Page 19

Metal-Film Resistor

is enclosed in sealed plastic casing

Low-noise metal-film resistor has a temperature coefficient of ±50 ppm C over temperature range from −65 to 164 C independent of resistance

RUTHMAN
GUSHER
COOLANT PUMPS
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STURDY
AS AN OX...
LONG LIVED
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1811 Reading Road
Cincinnati, Ohio

Circle 491 on Page 19

STANPAT SOLVES THE GHOSTING PROBLEM

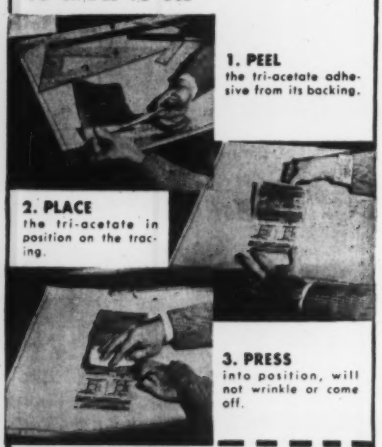
NEW resin-base STANPAT ELIMINATES GHOSTING, offers better adhesion qualities on specific drafting papers!

THE PROBLEM
Some of our longtime customers first called our attention to the "ghosting" problem. Certain tracing papers contain an oil which could be leeched out by the STANPAT adhesive (green back) causing a ghost.

THE SOLUTION
A new STANPAT was developed (red back), utilizing a resin base which did not disturb the oils and eliminates the ghost. However, for many specific drafting papers where there is no ghosting problem, the original (green back) STANPAT is still preferred.

WHICH ONE IS BEST FOR YOU?
Send samples of your drawing paper and we will help you specify. Remember, STANPAT is the remarkable tri-acetate pre-printed with your standard and repetitive blueprint items—designed to save you hundreds of hours of expensive drafting time.

SO SIMPLE TO USE



1. PEEL the tri-acetate adhesive from its backing.

2. PLACE the tri-acetate in position on the tracing.

3. PRESS into position, will not wrinkle or come off.

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Phone: FLushing 9-1693-1611

STANPAT CO. Whitestone 57, N. Y. U.S.A.

☐ Enclosed are samples of the drafting paper(s) I use (identify manufacturer). Please specify whether Rubber Base or Resin Base STANPAT is most compatible with these samples.

☐ Send literature and samples of STANPAT.

☐ Please quote price on our enclosed sketches which we are considering to have pre-printed.

NAME_____

FIRM_____

ADDRESS_____

CITY_____

ZONE____ STATE_____

Circle 492 on Page 19

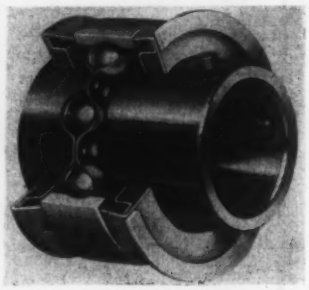
value. Assembly is enclosed in a hermetically sealed plastic casing to provide protection for precision resistor element. Standard tolerance is ±1 per cent. Two types are available, both with wire leads. Type WHM measures 1.125 in. long by 0.406 in. diam, and has maximum voltage rating of 500 v. Type WFH measures 0.781 in. long by 0.25 in. diam, and has maximum voltage rating of 350 v. **Resistance Products Co.**, 914 S. 13th St., Harrisburg, Pa. E

Circle 641 on Page 19

Machine-Unit Bearings

for light loads at normal speeds

Low-cost Simplex machine unit includes a single-row bearing of deep-groove design with extended inner ring, equipped with two setscrews for locking bearing on shaft. Separable seals can be used either singly or on both sides of bearing. Wire lock ring holds entire unit



securely in straight-bore housing. Bearings are available in shaft sizes from ½ through 1 3/16 in. Units are designed for light loads at normal speeds. **Hoover Ball & Bearing Co.**, 5400 S. State Rd., Ann Arbor, Mich. H

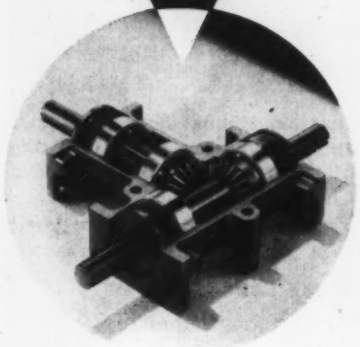
Circle 642 on Page 19

Thermal Time Delay

miniature unit has snap-action contacts

Series TH thermal device fills the need for a reliable, fixed time delay switching up to 20 amp. The miniature unit incorporates snap-action load contacts. Contact rating is up to 20 amp, with 10 amp standard. Relay is also available with magnetic blowout dc or double-break load contacts. It is

ANGLgear® simplifies your 90° drive problems



ANGLgear's hardened bevel gears and anti-friction bearings—exposed in the cutaway above—insure quiet, trouble-free operation. Being completely enclosed and permanently lubricated, unit requires virtually no maintenance.

Wherever you have a 90° power takeoff requirement in the ⅓ to 5 hp range, a standardized ANGLgear unit usually provides the simplest, most economical solution.

Compact, high-capacity ANGLgear offers you a number of advantages. Featuring universal mounting, it is easier to design into your power transmission systems; easier to install. Incorporating positive bevel gear drive, it eliminates slippage and minimizes backlash problems. Completely enclosed, it presents no safety hazard. Permanently lubricated, it requires little or no maintenance. And being standardized, ANGLgear is economically priced.

Standard ANGLgear is available from stock in ⅓, 1, 2¼ and 5 hp ratings, with choice of 1:1 or 2:1 gear ratios and 2 or 3-way shafting. See our literature in Sweet's Product Design File or contact our local distributor.

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Engineered Equipment for Aircraft and Industry

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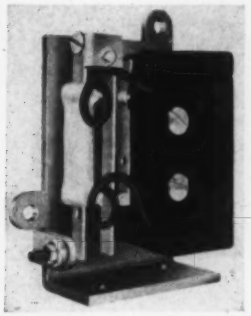
HILLSIDE 5, NEW JERSEY

Circle 493 on Page 19



furnished in explosionproof housings or hermetically sealed. Applications include air conditioning, refrigeration, exhause controls, heater controls, computers, lighting, and simple recycling. **Industrial Timer Corp.**, 1407 McCarter Highway, Newark 4, N. J. D

Circle 643 on Page 19

Nonflammable Adhesive

has high strength and heat resistance

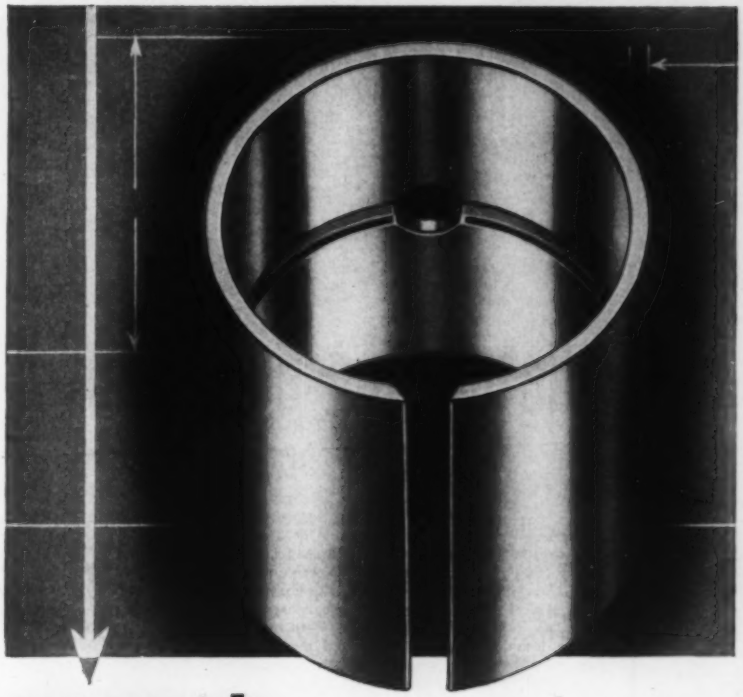
Bondmaster G459 adhesive bonds rigid and semirigid expanded polystyrene foams to themselves and to other materials such as wood, concrete, and metals. Formulation is water-dispersed, so that all danger of solvent attack on polystyrene foal cells is eliminated. Bonds resist humidity, resist freezing temperatures, and maintain strength through a temperature range of −35 to 250 F. Adhesive also withstands short-time exposure to 350-F temperatures. Formulation can be used for bonding insulating and sound-deadening materials to metal, wood, and to themselves. It is also applicable as a high-strength static-body adhesive for use where strong, waterproof bonds between porous or fibrous materials are required. Adhesive meets JAN-P-101, Type II, Grade A and Grade B. **Rubber & Asbestos Corp.**, 225 Belleville Ave., Bloomfield, N. J. D

Circle 644 on Page 19

Selenium Rectifier

miniature unit incorporates nylon seal

Series SP7K low-cost miniature rectifier has applications in radio and television, and in computers. Unit meets military environmental speci-



extremely rigid specifications!

The illustration shows the cast bronze spindle bearing of a very well-known and popular metal-working lathe.

The manufacturer of this lathe has extremely rigid specifications covering tolerances, finish, structural quality of the bronze and roundness of the bearing even though the bearing is split for its entire length.

A manufacturer with such requirements naturally turns to Bunting to satisfy them.

For the unusual, as well as the usual, in bearings, bushings, bars or special parts of cast bronze or sintered metals, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

...ask or write for your copy of...

Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

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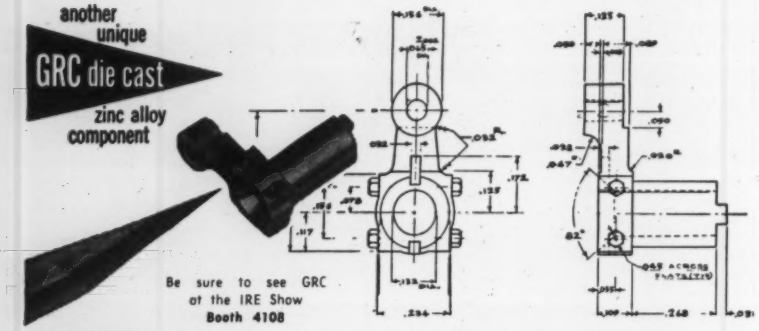
BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE OR SINTERED METALS.

Circle 494 on Page 19

another unique GRC die cast zinc alloy component



Be sure to see GRC at the IRE Show Booth 4108

GRC die casting helps Lionel achieve tiny part authenticity

This intricate toy crank was die cast in zinc alloy by GRC in a single automatic operation. Cost? Little more than $5.00 per thousand in lots of 500,000. Result? Produced quicker and more economically than Lionel could themselves. Less than half an inch overall, it is typical of the many small (maximum is 1¾" ½ oz., no minimum) parts problems solved by GRC's unique techniques. Gries' specialized machines deliver parts ready for use—uniform, accurate, clean —no trimming, no assembly, no scrap loss.

If you have a small parts problem, write, wire or phone for GRC's die casting bulletin or send prints for quotation.

World's Foremost Producer of Small Die Castings

GRIES

GRIES REPRODUCER CORP.
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Circle 495 on Page 19

COMPLETE HYDRAULIC FLUID FILTRATION FOR EVERY TYPE OF FLUID AND INSTALLATION.

FROM 0 to 5000 PSI.

NEW DATA SHEETS are ready for you . . . just off the press. You will see why and how Briggs dependability under stress and strain proves itself "more than able" to take shock and violent pressure rises and pressure drops without fatigue.

SEE FOR YOURSELF how Briggs dependability can help lower your operating costs, stop erratic production and "smooth" the way to fine, *continued* precision production.

Write for Briggs Hydraulic Data Sheets and our new booklet "Lubricating Oil Filtration." No cost, no obligation.

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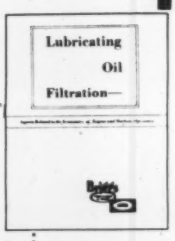
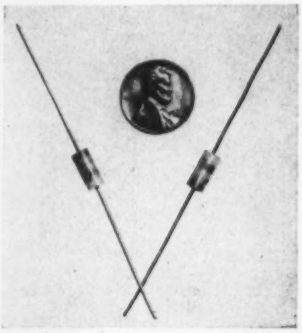
HYDRAULIC FLUID FILTERS OIL FILTERS.

PRODUCT OF BOOSTER RESEARCH



THE BRIGGS FILTRATION CO., WASHINGTON 16, D. C. Dept. 288
Send Hydraulic Data Sheets and new booklet "Lubricating Oil Filtration".
Name _____
Company _____
Address _____

Circle 496 on Page 19



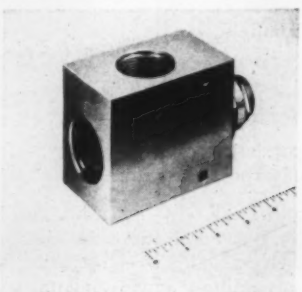
fications and performs efficiently over a wide temperature range to 125 C. Case length is ⅜ in. for 10 to 30-v unit and 17/32 in. for 40 to 80-v model, with 1½-in. leads. Peak inverse voltage ranges from 37 to 296 at 1 ma, with 0.2 ma reverse leakage at 25 C ambient temperature. Nylon seal resists humidity, salt spray, and fungus growth. **Bradley Semiconductor Corp.**, 275 Welton St., New Haven 11, Conn. B

Circle 645 on Page 19

Relief Valve

has capacity of 130 gpm

Designed to control pressure in hydraulic, lubricating, and fuel systems of ground handling and support equipment, pilot-operated valve is chatter-free and has capacity of 130 gpm. Externally adjustable pressure range is 50 to 1200 psi, and pressure rise is only 15 psi at 55 gpm. Valve shows negligible variations in pressure rise and hysteresis curves. Cartridge-type design permits overhaul without disconnecting lines and fittings. Internal leakage at maximum pressure is 5 cu in. per min maximum, and external leakage is zero. Valve weighs 4 lb, 11 oz and is designed for 3000-psi proof pressure and above 4000 psi burst pressure. Body is aluminum



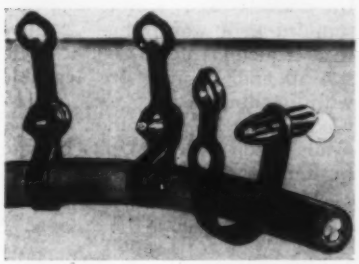
with stainless steel and aluminum cartridge. **Fluid Regulators Corp.**, 313 Gillette St., Painesville, Ohio. F

Circle 646 on Page 19

Self-Locking Fastener

for a variety of plastic parts

Pushlock consists of a series of molded flutes extending radially from a plastic stud. When stud is pressed into a hole of proper size, flutes deflect and tendency to return to original position creates a firm outward pressure, exerted uniformly around entire inside circumference of hole. Parts align perfectly and resist loosening even under severe shock and vibration in either wood or metal. Nuts and washers are not required. Adaptations can be made to specific



applications. Parts are especially suited for aircraft, missile, marine, automotive, and appliance applications where shock and vibration are serious problems. **Whitso Inc.**, Dept. MDC, 9330 Byron St., Schiller Park, Ill. I

Circle 647 on Page 19

Limit Switches

incorporate movable contact assembly

Designed for industrial operation, precision switches have an electrical rating of 600 v. The small, heavy-duty switches incorporate a movable contact assembly utilizing two compressed-coil springs to provide quick make and break action. Leak spring, carrying contacts, assures adequate contact pressure at all times, eliminates points of zero contact pressure, and provides nonteasing action even with extremely slow operating motion. Contact carrier spring affords sufficient contact wipe to assure good

Circle 497 on Page 19→

LONG LIFE, *THOMSON* "Snap-In"

NYLINERS®

of smooth, tough DuPont NYLON

Low Cost FLANGED Nyliner | Low Cost SLEEVE Nyliner | Low Cost DOUBLE-FLANGE Nyliner

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• COST LESS to BUY*
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& ELIMINATE LUBRICATION

Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
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- SELF-RETAINING
- RESIST CORROSION
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- LIGHTEST WEIGHT
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Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

**In production quantities at new, REDUCED PRICES.*

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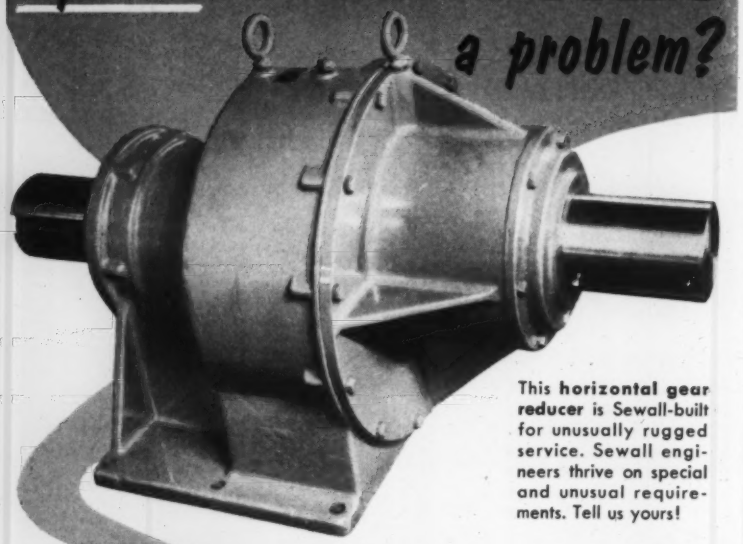
Also— —Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting

Special GEAR BOXES a problem?



This **horizontal gear reducer** is Sewall-built for unusually rugged service. Sewall engineers thrive on special and unusual requirements. Tell us yours!

Announcing!

Whether you need gear boxes such as this worm gear reducer in custom or mass produced quantities, it will pay you to talk to Sewall.

A new Sewall Service . . . designing, development and manufacturing . . . to help solve your special gear box problems . . . effectively . . . economically. We're ready to work with you at any stage of your project's development.

From scratch . . . our gear box designers will go to work for you right now. Give us a rough outline of your idea. We're staffed and equipped to design and manufacture gear boxes whatever the size and description of your requirements.

To your specifications . . . let us submit our quotation on producing your order in strict accordance with your prints. Sewall gear boxes are made by men who are fussy about specifications. Your order must be delivered as scheduled . . . priced right. Let us hear from you!

Sewall's complete gear service can help you . . . custom made gears . . . made-to-order sprockets . . . special gear racks—to order . . . standard gear racks in stock.

For the complete service . . . design . . . development . . . manufacturing . . . on **special gear assemblies** (sample illustrated) call Sewall.

SEWALL GEARS

E. B. SEWALL MANUFACTURING COMPANY

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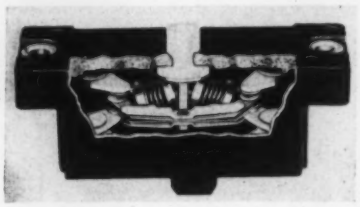


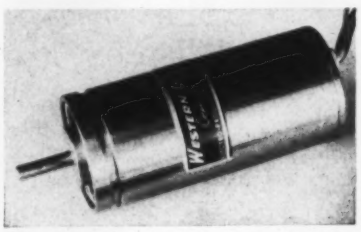
electrical contact on low voltage. Switches are completely enclosed in a semidust-tight, molded phenolic case of high physical strength and arc-resisting capacity. Wide variety of operators is available. **Cutler-Hammer Inc.**, 328 N. 12th St., Milwaukee 1, Wis. K

Circle 648 on Page 19

Geared Servomotors

are available in sizes 10 and 11

Integral-gearhead servomotors are supplied in a wide range of ratios with reductions up to 8000:1. The size 10 and 11 units are available with windings for 26, 55, or 115 v ac, 400 cycle, with other voltages available on order. Units operate in ambient temperatures from −65



to 125 C, and are 2-17/64 in. long. **Electro Products Div., Western Gear Corp.**, 132 W. Colorado St., Pasadena, Calif. L

Circle 649 on Page 19

Magnetic Contactors

mount in any position

Class 41 contactors are rated in 20, 30, and 40-amp sizes for air conditioning and refrigeration. They are also rated through 10 hp, 220 v, and 15 hp, 550 v polyphase for across-the-line control of electric motors, heating, and lighting loads. Same controls are also rated for resistance-heating loads through 40 amp. Contactors with 550-v ratings have replaceable contacts, and replaceable, moisture-resistant coil. The 20, 30, and 40-amp sizes in

two, three, and four-pole devices have same mounting dimensions. Solenoid assembly is silicon steel, and sealing surfaces are precision ground to provide quiet operation. Once solenoid starts to pull in, it automatically follows through all the way to sealed position without hesitation at point of contact make.

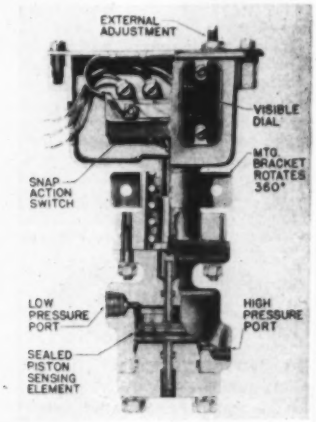
Pressure terminals reduce wiring time. **Furnas Electric Co.**, 1045 McKee St., Batavia, Ill. I

Circle 650 on Page 19

Differential Switch

senses 5 to 140 psi difference between two pressures

Pressure difference switch is particularly suitable for filter installation. When filter becomes clogged, switch senses pressure difference across filter inlet and outlet and actuated warning circuit. Sealed piston sensing element actuates electric circuit upon increasing or decreasing of a predetermined pressure difference. Unit senses difference from 5 to 140 psi between two pressures. It is applicable to oil systems ranging from 50 to 6000 psi working pressure. Proof-pressure rating of 9000 psi gives protec-



"MEMORY" RELAYS
These famous Dunco mechanical latch-in, electrical re-set units are available in practically any needed contact or mounting arrangement in power or midget types for either AC or DC operation. Write for Data Bulletins 4050 and 4051.
SEQUENCE RELAYS
Multipole — repeating — reversing and electrical reset types provide a wide range of contact sequences for positive automatic control applications. Write for Dunco Data Bulletins 5100 and 5200 for full details.

high reliability

WAS BUILT INTO THESE *Dunco* RELAYS YEARS AGO . . .

and fully proved in thousands of applications

Bypassing newer relay types for the moment, it frequently pays to look to the older units where unquestioned dependability is a matter of prime concern. Built for real durability, proved in years of the toughest kind of field service, these famous Dunco standard types offer sound basic design that has stood the test of the years. And, in addition, there is plenty of proof that they do all that the finest, most reliable relays of these types are supposed to do.

STRUTHERS-DUNN

Makers of the world's largest assortment of relay types

STRUTHERS-DUNN, Inc., Pitman, N. J.

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Circle 499 on Page 19

Features that set them apart from whatever is "second-best"!

Cutaway view of TRE Male Rod End.

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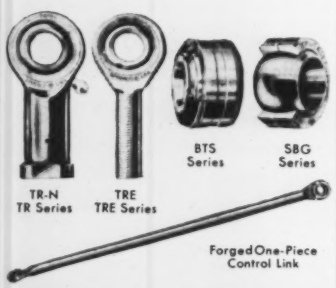
SPHERICAL BEARINGS & ROD ENDS

Quality SPHERCO Bearings and Rod Ends are precision built for superior performance. They are available in a wide range of sizes of varying design and materials to meet specific requirements. A SPHERCO engineer in your area will be happy to help you with your problems.



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A PRODUCT OF
SEALMASTER BEARING DIVISION
STEPHENS-ADAMSON MFG. CO.
18 RIDGEWAY AVE. • AURORA, ILL.

Circle 500 on Page 19

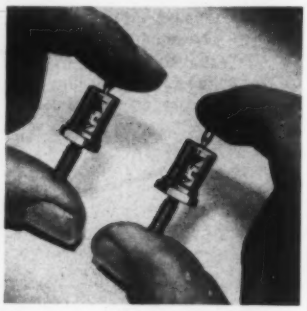
tion against damage from sudden surges and shock loads. Fixed actuation value of switch is from 5 to 15 psi, depending on working range of system. **Barksdale Valves**, 5125 Alcoa Ave., Los Angeles 58, Calif. L

Circle 651 on Page 19

Silicon Rectifiers

are stud mounted for good heat dissipation

Type 66-2730 and 66-2731 rectifiers are designed primarily for high-temperature operation. Stud mounted for optimum heat dissipation, they can be operated at temperatures to 150 C. High minimum inverse voltage of 1500 v, combined with ability to withstand severe



shock and vibration, makes rectifiers suitable for missile and airborne equipment applications. Proper selection of polarity (Type 66-2730 with cathode mounting, or Type 66-2731, anode mounting) eliminates need for high-voltage insulation between stud and chassis. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif. L

Circle 652 on Page 19

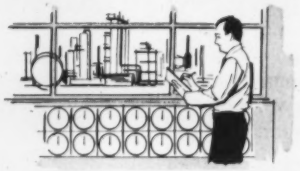
Transistorized Accelerometer

operates at ±15 g vibration through 2000 cps

Used to close a set of contacts at predetermined velocities and to provide analog outputs relative to acceleration and velocity, transistorized integrating accelerometer withstands a variety of environmental conditions. Analog outputs are used in turn to actuate various control functions. Velocity contacts can be closed at any speed from a few feet per second to 50,000 fps to accuracies of 0.25 per cent over extended

SPECTROL PRECISION MECHANISMS

One Man, Black Boxes, and Process Control



Speeding up instream process control frequently requires more ingenuity than cash.

Bearing on this point, Spectrol recently made a number of cleverly engineered black boxes for one of the country's leading refineries. This device, known as an Indicating Process Monitor, takes inputs from flow, temperature, and pressure transducers, measures them and delivers any necessary corrective action through a servo loop. The information is visually presented on dials incorporating adjustable set points. Output from this Spectrol black box also drives a variety of data handling, display, and recording equipment.

Here's how it works. After a given physical quantity is transduced to a voltage, it passes through a difference sensing network to a servo-amplifier. The amplifier output voltage operates a motor and speed reducer which drives several Spectrol precision potentiometers ganged on a common shaft. The output voltage of one of these potentiometers has a linear relationship to the indicator setting and is used for negative feedback. The difference between this voltage and the transducer input voltage becomes the servo error signal. Rotation of the system continues until the error signal becomes zero and the indicator reads the new value of the physical quantity under consideration. Meanwhile, other potentiometers on the shaft send voltages to various instream control devices which raise and lower pressures, temperatures, and so forth until the process takes place at the desired rate. Static accuracy is 0.2%.

The visual monitoring task of the observer is simplified by mounting the meter on an easily rotated chassis so that anticipated output in terms of arbitrary units from 1 to 100 can always be read with the needle in an upright position. This feature minimizes observer error where several predetermined outputs are viewed continuously. If black box A is set at 85, B at 40, and C at 100, the operator merely rotates each Spectrol precision mechanism until the respective needle reads the value in an upright position. He can quickly note and correct any processing circuit that leaves boundary conditions.

Of course, these devices are readily adaptable to the more esoteric tasks of reading fuel flow, pressure and temperature in a missile launch blockhouse. Here, human engineering of visual displays is of vital concern.

In a nutshell, advantage of this instance of Spectrol's unique approach to automation is a package one-fifth the size for 40% less than the way the refinery used to do the same job.

More information, including a helpful 8 page booklet, on this and other Spectrol precision mechanisms designed for use as functional sub-systems is yours for the asking. Simply call your nearest Spectrol sales engineering representative or address Department 573

8

SPECTROL
ELECTRONICS CORPORATION
Sales engineering representatives in principal cities.
1704 S. DEL MAR AVE., SAN GABRIEL, CALIFORNIA

Circle 501 on Page 19

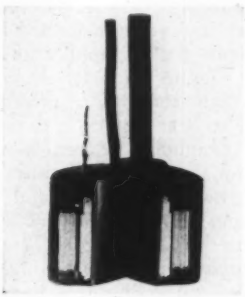
operational periods. Pressure range is 0 to 35 psi absolute, and temperature range is 30 to 150 F. Unit operates at ±15 g vibration through 2000 cps. Acceleration ranges from ±1 to ±20 g, with greater range also available. Accelerometer stands short shock pulses of 75 g and long pulses of 50 g. **Transducer & Systems Dept., Donner Scientific Co.**, Concord, Calif. M

Circle 653 on Page 19

Ignition Coil

for small two and four-cycle engines

Wound with small-diameter conductors and impregnated with epoxy plastic, ignition coil is protected from chemical attack, is impermeable to moisture and humidity, and is protected from physical shock. Unit is available for small two and



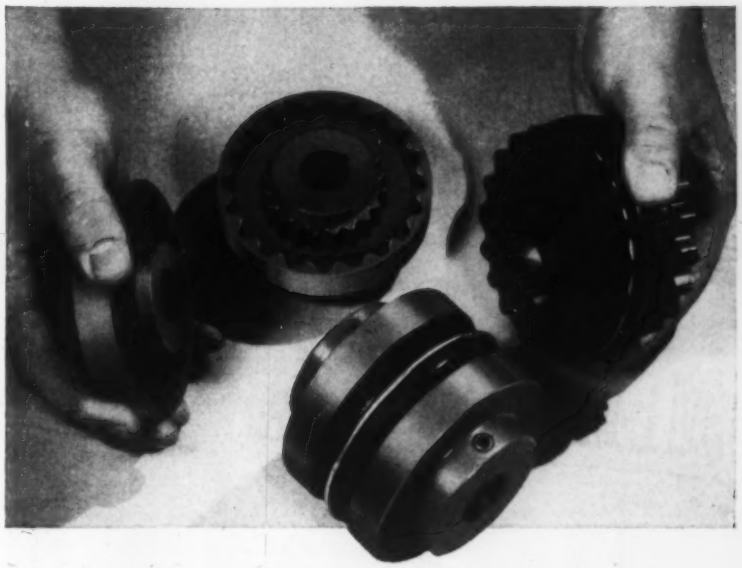
four-cycle industrial engines. **Pacific Mercury**, 14052 Burbank Blvd., Van Nuys, Calif. L

Circle 654 on Page 19

Control Valves

are operated by single or double solenoids

Type B, ½-in. poppet pilot control valves combine rugged construction, compact design, and zero leakage. The single or double-solenoid-operated units have housings of alu-



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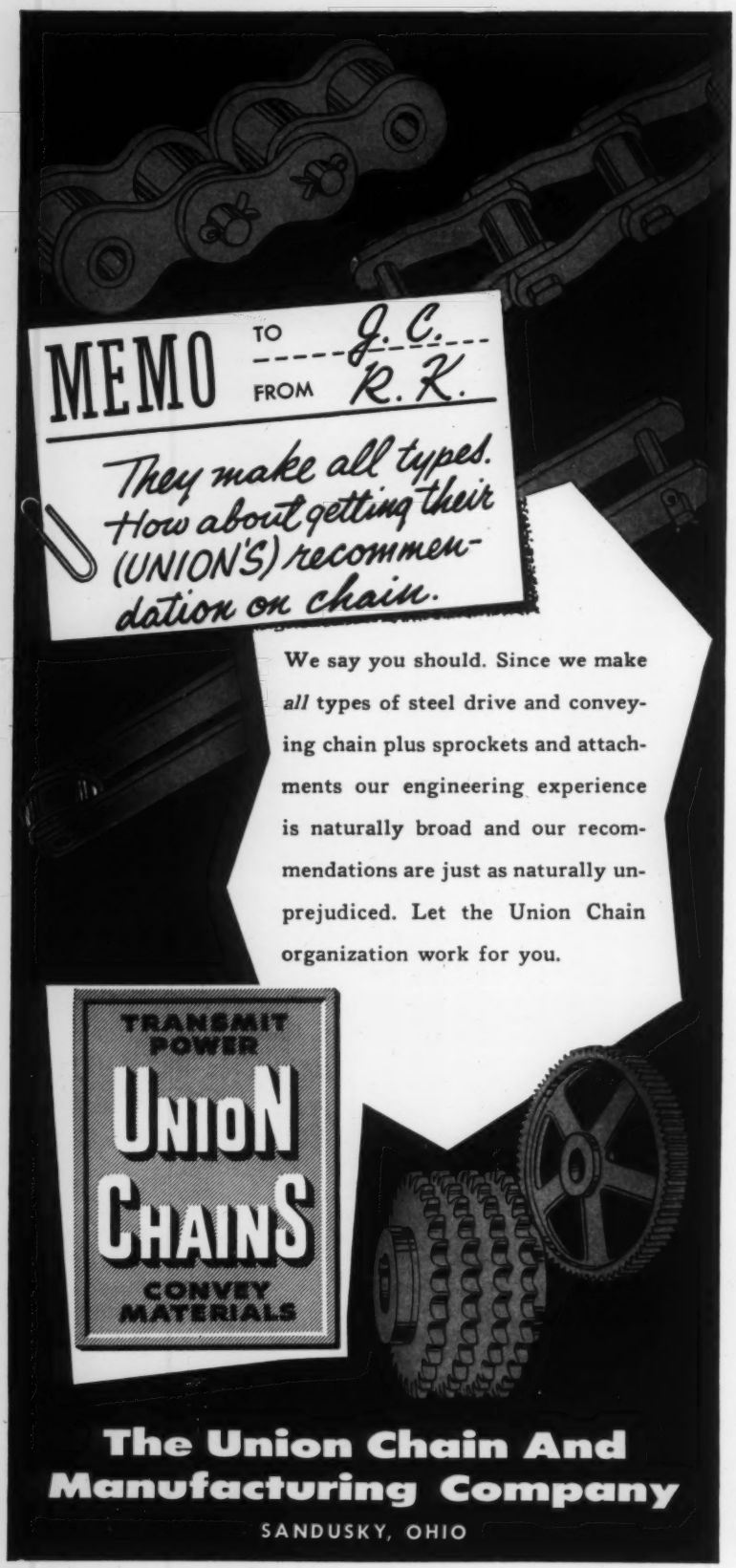
Circle 502 on Page 19


MEMO
TO J. C.
FROM R. K.
They make all types. How about getting their (UNION'S) recommendation on chain.
We say you should. Since we make all types of steel drive and conveying chain plus sprockets and attachments our engineering experience is naturally broad and our recommendations are just as naturally unprejudiced. Let the Union Chain organization work for you.
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The Union Chain And Manufacturing Company
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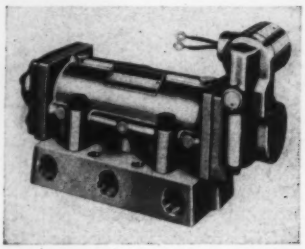
minum castings. Valve chambers in straight-through bore are formed with metal spacers that position packings accurately and support them on both ID and OD without placing them under mechanical pressure. Flow is through hollow, radially ported, stainless-steel



plunger and out connected piping. Pilot operation employs fluid pressure to operate valve, permitting use of small, short-stroke solenoids. Valves are available in all customary ac and dc voltages. They are furnished in two, three, and four-way actions. **Hunt Valve Co.**, Salem, Ohio. G

Circle 655 on Page 19

Rigid Vinyl Sheeting

provides greater resistance to impact, light, heat

Three rigid vinyl sheeting materials can be formed, machined, drilled, trimmed, and vacuum formed readily. They are for applications requiring higher impact strength, greater light stability, or greater resistance to heat distortion than previously available. Materials retain dimensional stability, chemical inertness, nonflammability, and freedom from odor attributed to vinyl materials. VCAB-3603 is for applications requiring unusually high impact strength. Sheeting has flexural strength of 10,500 psi and Izod impact resistance of 15 ft-lb. For applications requiring superior light stability and high impact strength, VCAB-3604 is furnished, in a variety of colors in translucent and opaque sheeting. Greater resistance to heat distortion of VCAB-3606 makes it particularly valuable in applications requiring proximity to heat or light. **Union Carbide Plastics Co., Div., Union Carbide Corp.**, 420 Lexington Ave., New York 17, N. Y. C

Circle 656 on Page 19

Circle 503 on Page 19

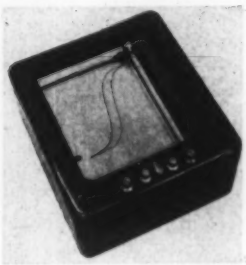
ENGINEERING DEPARTMENT

EQUIPMENT

X-Y Recorder

uses self-balancing potentiometer servos

HR-92 recorder is used for computer readout and for plotting stress vs. strain, magnetic-material, tube and semiconductor characteristics, pressure vs. temperature, speed vs. torque, or any other two related variables. Unit is designed for use with standard 8½ x 11-in. graph paper. Use of self-balancing potentiometer servos assures 0.5 per cent accuracy and drift-free performance at available sensitivities of up to 1



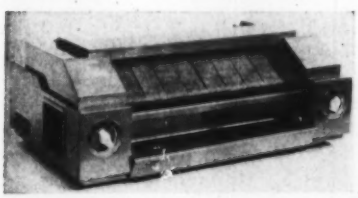
mv per in. Pen speed is 1 sec full scale without overshoot. **Houston Instrument Corp.**, 1717 Clay Ave., Houston 3, Tex. P

Circle 657 on Page 19

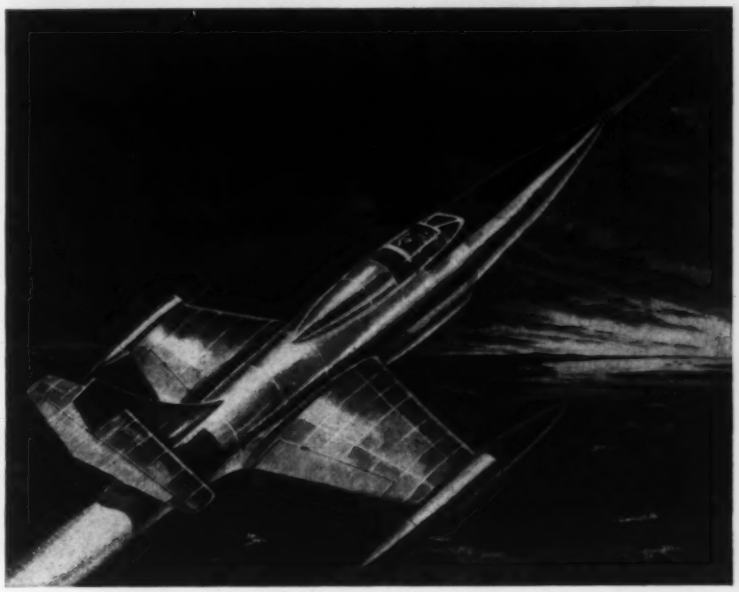
Whiteprint Machine

has 18-in. printing width

Reprofax Viking, with printing speeds up to 18 fpm, produces up to 450 sharp, evenly developed copies per hour. Unit has full 18-in. printing width for processing two letters side by side or for reproducing 18-in. wide drawings of



Penetrate the Thermal Barrier



MicroMach extra-high-tensile stainless steel sheets up to 48" WIDE for aircraft and missile use

As the speed of today's aircraft rapidly approaches the Thermal Barrier, conventional metals are being left far behind in the race to satisfy the structural requirements of supersonic craft. Needed are metals that can withstand the intense heat caused by air friction at high speeds and still retain their strength. One such metal, MicroMach stainless, has been in use for more than a year.

MicroMach is a special aircraft and missile grade of modified type 301 stainless steel sheet furnished to higher mechanical properties than are available in other commercial high tensile grades in the full hard condition.

These sheets are rolled to extremely close tolerances (as low as plus or minus 3%) with micro-accuracy and precise uniformity of gauge. The surface of MicroMach sheet is smooth, clean and dense; qualities so important in minimizing surface friction.

MicroRold stainless steel is also available in all popular grades and to meet regular government specifications. Sheets up to 36" wide can be had as thin as .005", and over 36" to 48" wide as thin as .010" in all commercial finishes and tempers.

For further information write to Aircraft Steels Dept.

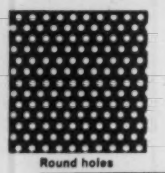
Washington Steel Corporation

3-E WOODLAND AVE. WASHINGTON, PA.

Circle 504 on Page 19

LET H&K PERFORATED MATERIALS

put personality into your products

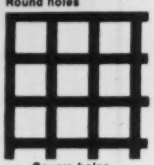


Round holes

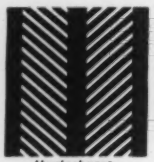
Whenever—wherever—your products require perforated materials, you will find the pattern and open area "just right" for that custom-look in the vast selection of H & K existing dies.

Modern facilities and H & K experienced craftsmanship, enable the perforating of practically all metals, wood, compositions and plastic. Perforated materials can be furnished in sheets, coils, rolls or plates. Fabricating services include shearing, rolling, welding and forming.

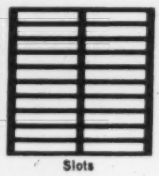
Illustrations shown in reduced size



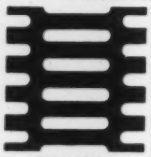
Square holes



Herringbones



Slots



Oblong holes

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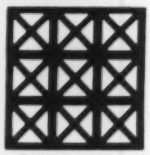

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Circle 506 on Page 19

HUMAN-FACTORS ENGINEERING

by John D. Vandenberg and C. Thomas Goldsmith

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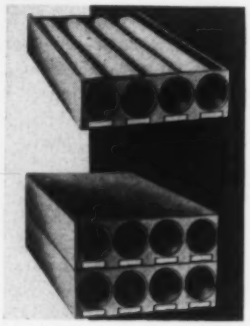
any length. Copies can be obtained of anything printed, typed, written, or drawn on ordinary translucent paper. Unit operates on standard 115 v ac, 60 cycles. Constant-wattage transformer stabilizes light output from 800-w printing lamp, despite voltage fluctuations. **Reproduction Products Co.**, 12790 Westwood Ave., Detroit 23, Mich. H

Circle 658 on Page 19

Tube Filing System

for rolled prints, charts, drawings, and maps



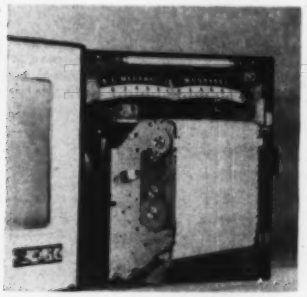
Plan Hold roll file consists of modular steel-encased tubes in units of four tubes per roll file. Units measure 12 in. wide by 4 in. high by tube length of either 27 or 33 in. The 2⅜-in. ID tubes hold rolled prints, charts, drawings, maps, or tracings. Stacking feature enables units to be assembled for desk-top mounting or under-surface table mounting by means of a slide-on top provided with mounting holes for suspension. Steel filing cabinet with cylinder lock in handle accommodates a total of 12 units (48 individual tubes). **Plan Hold Corp.**, P. O. Box 1038, South Gate, Calif. L

Circle 659 on Page 19

Duplex Recorder

provides double record on a single roll

CH37 general-purpose recorder plots two related electrical quantities side by side on a single chart, permitting faster reading. It helps to eliminate reading errors associated with matching separate charts when correlating quantities such as watts and vars, volts and frequency, or wind direction and speed. Low-burden, fast-response recording ele-



ments trace on two 4-in. calibrated charts printed on a 10-in. wide record roll. Recorder is available with a complete set of rate gears and either a single-speed synchronous motor giving 11 chart speeds from ¼ to 30 iph, or a double-speed motor offering 28 speeds from ¼ iph to 120 ipm. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 660 on Page 19

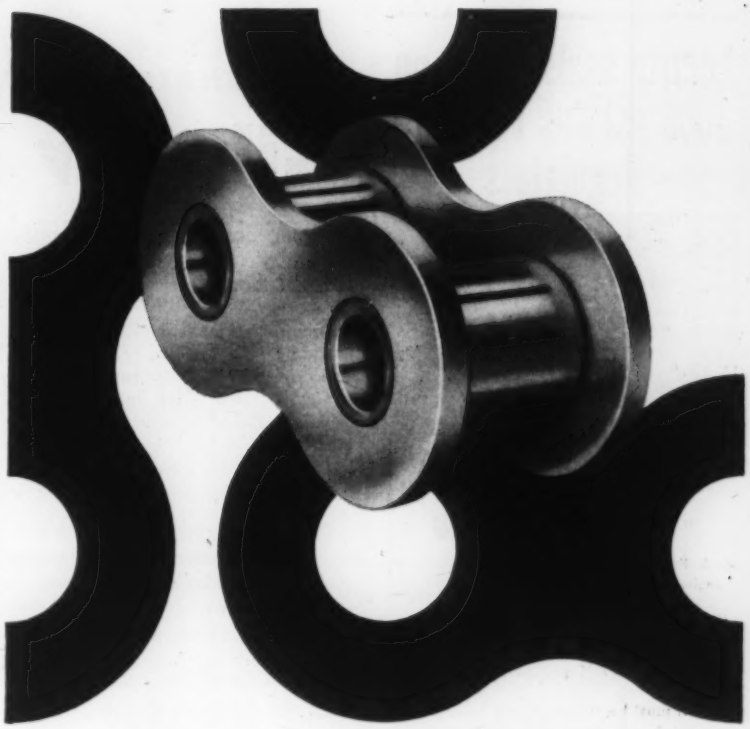
DC Power Supply

transistorized unit provides 24-32 v at 10 amp

Model MTR28-10 transistorized precision laboratory dc power supply incorporates a dual regulatory system consisting of magnetic amplifier and transistor amplifier. It operates from an ac input of 105-125 v, single phase, 60 cps. Unit provides 24-32 v at 10 amp and incorporates automatic current limiting for protection against dangerous overloads and dead short circuits. Regulation is ± 0.1 per cent for slow (static) line and load changes, ± 0.1 per cent for line, ± 0.4 v

for load, on instantaneous (transient) line changes of 10-v magnitude and load changes from no load to full load and full load to no load. Output impedance is 0.05 ohm maximum, and ripple is 2 mv rms. Supply offers positive protection of transistorized circuits. **Perkin Engineering Corp.**, 345 Kansas St., El Segundo, Calif. L

Circle 661 on Page 19



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And Whitney's complete line of standard, finished steel chain drives insure adaptability to the widest range of power transmission and conveying requirements. Available through field warehouses and nationwide distributor service. Write for helpful, practical catalog literature.

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For complete motor overload protection, cushioned starts and high efficiency, ask about our new permanent magnet, self-contained power transfer units. Available in 1, 2, 3 and 5 H.P. units as stock items, additional sizes up to 15 H.P. will follow . . . Write for new 8 page Technical Bulletin. Box 318C-TOR

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Circle 507 on Page 19

Loctite seals joints on 3000 psi Gas Pressure Regulators . . .

Mr. A. W. Zmuda, Chief Engineer C. A. Norgren Company, Englewood, Col., says:

"There are three basic requirements for the sealant used in the assembly of our new type 20AN pressure regulators:

1. **It must be a thread seal suitable for high pressure CO_2 up to 3000 psi.**
2. **It must be a sealant that will permit the joint to be broken for servicing without undue difficulty.**
3. **It must be a sealant that does not contain solid particles, such as lead, which might find their way into the stream because of the necessity for cleanliness in the valve area.**

LOCTITE fulfills these requirements better than any sealant we tested."

Liquid Loctite hardens between metal parts to form a tough heat and oil-resistant bond completely filling the joint to insure a positive seal. Hardened Loctite is not affected by water, military fuels, hydraulic fluids, degreasing solvents and most chemicals.

Loctite application is suited to mass production . . . requires no heat or mixing. Treated parts can be stored for days . . . lock only when assembled. Any Loctite outside the joint remains liquid and may be wiped off leaving no residue to enter fluid stream.

Loctite seals pipe and tubing joints . . . locks nuts to bolts . . . eliminates need for interference fits for bearings, sleeves, shafts and studs. Write for literature and free sample.

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Circle 508 on Page 19

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Recent Books

Mechanics—Part I: Statics, Second Edition. *By J. L. Meriam, professor of engineering mechanics, University of California; 393 pages, 5¾ by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN; *$5.00 per copy postpaid.*

Aiming to develop thought transition between the physical situation and its symbolic representation, this book emphasizes the few fundamental principles of mechanics and their application. Revisions include new illustrations and problems related to engineering activities, a rewriting of fluid statics, and a section on vector methods.

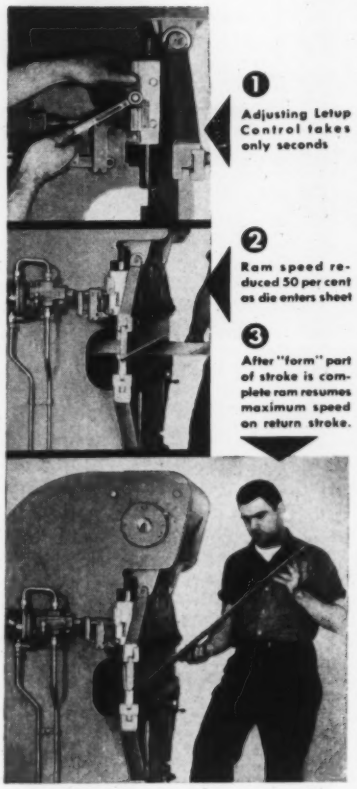
Machinery's Mathematical Tables, Second Edition. *Edited by Holbrook L. Horton; 254 pages, 4½ by 7 in., clothbound; published by and available from The Industrial Press, 93 Worth St., New York 13, N. Y.; $3.75 per copy.*

Tables are photographed directly from *Machinery's Handbook*. Added to this edition are tables of natural logarithms; logarithms of trigonometric functions; English and metric weights, measures, and conversion factors; geometric propositions and constructions; dimensions, areas, and volumes of plane and solid geometric figures; prime numbers and factors; and radian measure.

Association Publications

Diaphragm Characteristics, Design and Terminology. *By Floyd B. Newell; 74 pages, 8½ by 11 in., paperbound, stapled; published by and available from American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $3.75 per copy.*

After defining diaphragm performance characteristics, the author describes methods of measuring and representing them, and tells how they are related, applied, and affected by design details and manu-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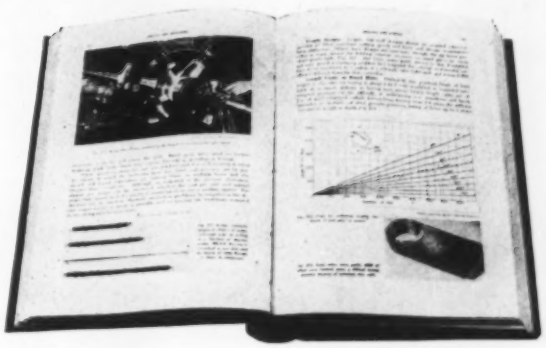

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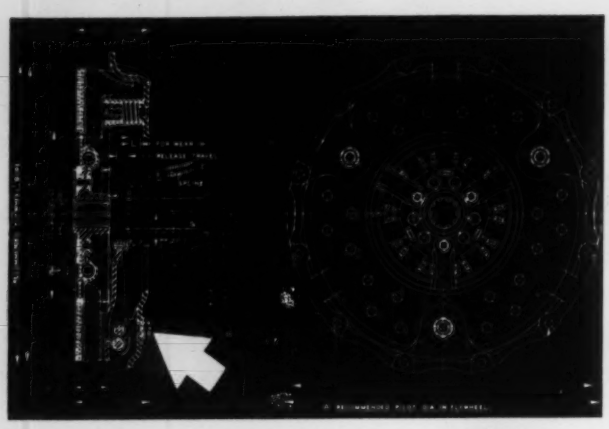

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facturing processes. Diaphragm limitations, design equations and methods, and representative applications are included.

The Management of Scientific Manpower—Management Report 22. 160 *pages, 6 by 9 in., paperbound; available from American Management Association Inc., 1515 Broadway, New York 36, N. Y.; $3.75 per copy.*

Current industrial practices of research and engineering management are described. Sections on broad policy planning and organization, and on recruiting and hiring engineers and scientists are based upon previously presented papers. A special supplement discusses additional training for engineers and engineering management.

Mechanical Impedance Methods for Mechanical Vibrations. *Edited by Robert Plunkett; 145 pages, 8½ by 9 in., paperbound; available from American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $5.50 per copy.*

Because the impedance approach to vibration analysis is new to mechanical engineers, colloquium papers emphasize presently available methods and information. Based upon the ratio of sinusoidal excitation to resulting response, the method can be applied to linear dynamic systems of rather high complexity. Definitions, measurement techniques, and examples of method application, including use of high-speed computers, are presented.

Government Publications

OTS Technical Reports. *Copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

The following reports are available:

PB 131785. A Vibration Manual for Engineers, Second Edition. By R. T. McGoldrick, U. S. Navy; 32 pages, 8 by 10¼ in., paperbound, stapled; $1.00 per copy. (Revised collection of formulas, with illustrations and graphs, for mechanical vibration problems; used by Structural Mechanics Div. of David Taylor Model Basin.)

PB 131799. The Effect of Temperature on the Magnetic Properties of Nickel-Iron Alloys. By J. J. Clark and J. F. Fritz, for WADC; 36 pages, 8¼ by 10¾ in., paperbound, stapled; $1.00 per copy. (Magnetization, saturation, remanance, and coercivity curves show dc magnetic properties of toroidal cores wound from 2 mil tapes of Hypernik, Hypernik V, Deltamax, Mo-Permalloy, Supermalloy, and Hymu 80 from —60 C to +250 C.)

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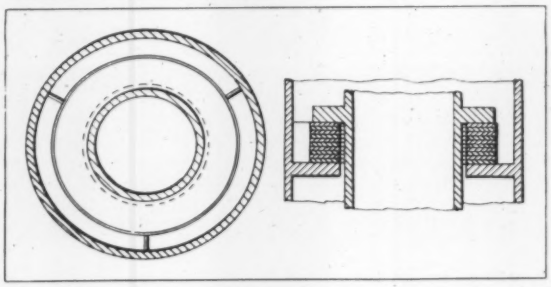
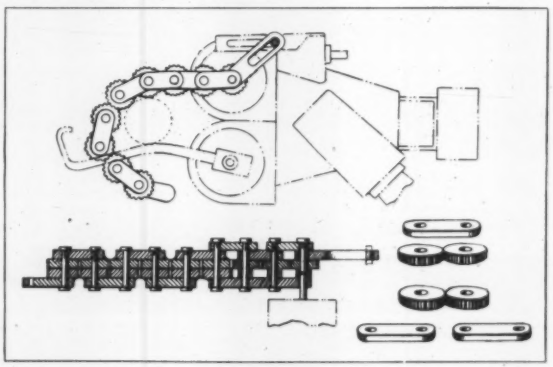
Patents

Metallic Heat Insulator



Multiple layers of metal washers perform four functions in a jacketed tube which carries very cold liquified gas, such as oxygen or hydrogen. Washer material is stainless steel or Monel metal in thicknesses of 0.0005 to 0.005 in. Stacked ½ to 1-in. thick, overall, the washers function as load supports, physical spacers, thermal barriers, and gas-pressure seals. Optimum values of the latter two properties occur at a relatively low vacuum. Low thermal conductivity of stacked laminas is attributed to small contact area between adjacent washers despite high surface finish. Heat loss through a stack of washers is as little as 1/200th the loss in a solid piece of the same material and overall size. *Patent 2,871,042 assigned to the United States of America (Atomic Energy Commission) by Bascom W. Birmingham, Edmund H. Brown, Russell B. Scott, and Peter C. Vander Arend.*

Articulating Linkage



Like the trunk of an elephant, an assembly of gears and links curls with respect to a fixed hook (tusk) to grip, carry, and release objects in a wide range of sizes. The assembly is a remotely controlled manipulator for use in dangerous environments. A motor at the "head" end powers the linkage. At the same place, two slotted

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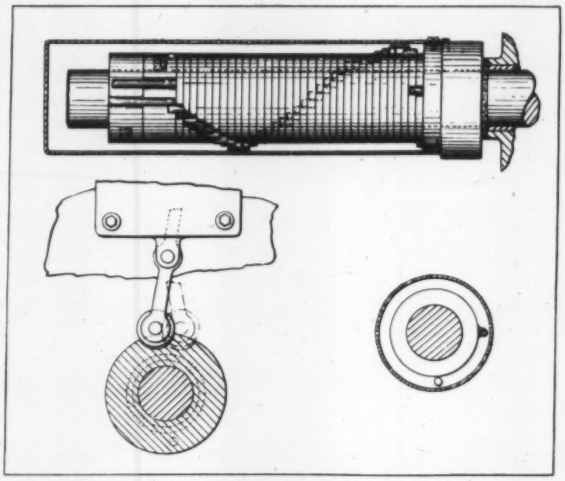
links joined by a pin adjust the size of grip. The links are arranged in an alternately opposed manner. Those nearest the motor are fixed to each other, and their gears, engaged, rotate on link pins. At the other end, links are fixed to adjacent gears, and link pins serve as pivots. Links fixed to links form a power-transmission chain. Links fixed to gears transmit motion. *Patent 2,869,139 assigned to General Electric Co. by Ralph S. Mosher.*

Woven-Wire Cushion

A compound unit which damps vibration and absorbs shock loads is composed of two kinds of knitted-wire fabric rolled together into the form of a cylinder. One fabric is loosely woven of wire having substantial spring temper. The other fabric, less flexible, has a smooth, flat mesh. As the two join, the spring member is flattened and corrugated to increase its flexibility and to make its overall width equal to that of the other fabric. In the assembly, the uncorrugated fabric adds damping capacity and spaces the corrugations of the spring wire. *Patent 2,869,858 assigned to Metal Textile Corp., Roselle, N. J., by Ralf L. Hartwell.*

Mechanically Timed Reversing Drive

Continuous reversing of a power source, such as an electric motor, is provided by an assembly of a number of discs free to rotate on the power source shaft. The interval between reversals can be expressed in units



of time or shaft revolutions. Fixed on its circumference, each disc carries a pin which projects beyond one face of the disc a distance less than one disc thickness. At the ends of the disc stack are control discs fixed to the common shaft, as with setscrews, also carrying pins on their circumferences. As the shaft rotates, one control disc accumulates plain discs, by abutment of successive pins, at the rate of slightly less than one per shaft revolution. Accumulation of all the discs results in positive tripping of an electric switch which reverses the motor. This change of rotation initiates reverse accumulation of discs. *Patent 2,836,991 assigned to Western Precipitation Corp., Los Angeles, by David B. Perlis.*

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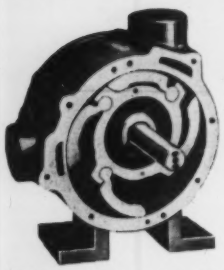
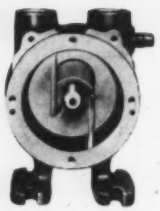


Metal Vanes take up their own wear



4-VANE TYPE. Vacuums to 20" Hg.; pressures to 15 lbs.; displacement to 162 c.f.m. Vanes hinged to pistons maintain continuous sealed contact with cylinder walls by centrifugal force. Small pistons, large air chambers, greater capacity.

2-VANE TYPE. Vacuums to 29.9" Hg.; pressures to 20 lbs.; displacement from 2.4 to 105 c.f.m. Automatic Vane adjusting lever forces wear-resistant steel blades to cylinder walls, preventing sticking or binding, maintaining positive vacuum or pressure.

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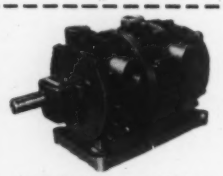

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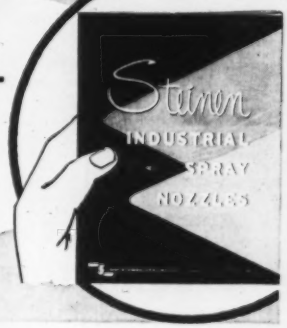

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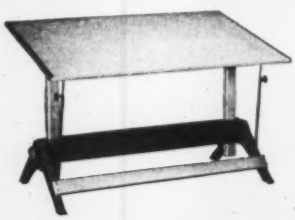

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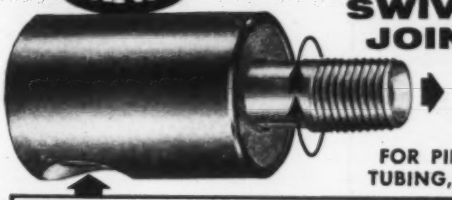

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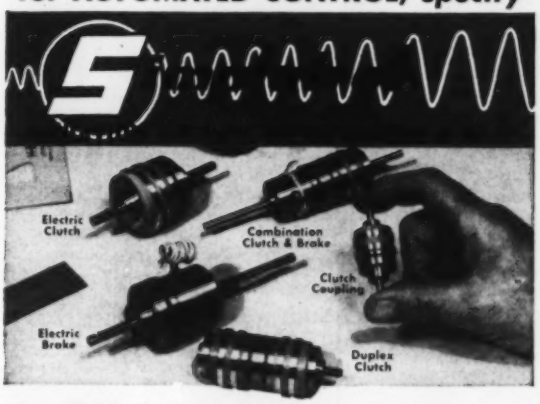

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- Silent action, eliminates magnetization of surrounding parts
- 5 standard styles; full range of sizes — ⅞" to 3⅛" diameter

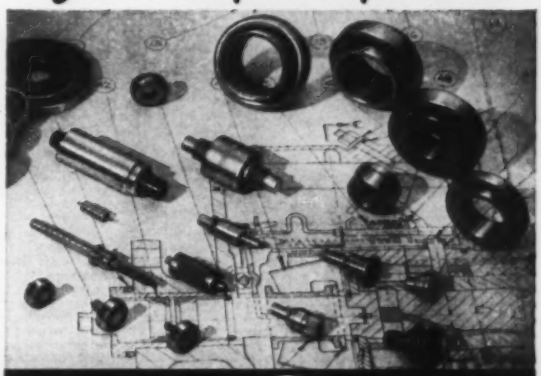
Check your requirements for electric clutch and brake control. You'll find SIMPLATROL Miniature and Small Electric Clutches and Brakes upgrade new machine performance, give faster, more precise sequence operations.

Ask for recommendations on Simplatrol units. New illustrated folder on request.

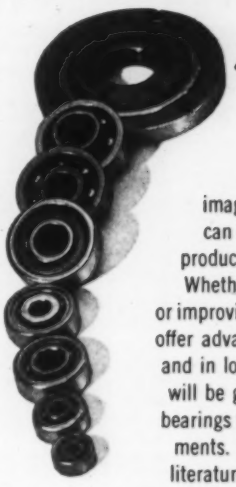
Simplatrol products corp.
24-S SALISBURY ST., WORCESTER, MASS.
Representatives in Key Industrial Areas

Circle 524 on Page 19

BEARING ideas *for design engineers*



VERS-O-LINE
bearings by Hartford
ENGINEERED TO BE PART OF YOUR PRODUCT



Types

- Radial—H-Series
- Radial—Conrad Loaded
- Radial—Full Complement
- Thrust
- Versa-Twin—Twin Row

Vers-O-line bearings challenge the imagination. In many applications, they can be engineered so that parts of your product can form the inner or outer races. Whether you are designing a new product or improving an old one, Hartford Vers-O-lines offer advantages in performance, unitization and in low cost. Hartford bearing engineers will be glad to adapt or design Vers-O-line bearings to meet your exact product requirements. Write for comprehensive technical literature. Contains standard Vers-O-lines, case history applications, and bearing ideas that can be helpful to you.

Hartford
PRECISION BALLS • BEARINGS

Hartford Steel Ball Co., Inc.,
94 Jefferson Avenue, W. Hartford 6, Conn.

Circle 525 on Page 19

FHP motors... engineered especially for your product

The new RAE M-40 Series, in 3 ratings at 5000 RPM. AC/DC Universal or DC Shunt. M-41 and M-42 rated ½ H.P. M-43 and M-44 rated ¾ H.P. M-45 and M-46 rated 1 H.P. Available with any of Rae's gear units.

RAE motors

RAE engineers are recognized specialists in solving difficult FHP motor applications. By careful analysis and testing of your product, they can save you time and money in selecting the right motor.

RAE offers outstanding service and quality in a large variety of motors. Available in voltages up to 250, and up to 1/2 H.P. (higher for intermittent duty) with many gearhead motor combinations.

Find out how RAE motors can *improve your product* and *reduce costs* as they are doing for other leading manufacturers.

***Send for the "RAE" Engineering Data Sheet. It will help you supply the data necessary for recommendations and prices.**

Rae MOTOR CORP.
2009 Kewaunee Street
Racine, Wisconsin

AC/DC Universal • DC Shunt Wound • DC Series Wound • Gear Reduction Motors • Governor Controlled Motors • Motors for Rheostat Control • Motors for Electronic Control • Permanent Magnet Motors and Gearmotors.

Circle 526 on Page 19

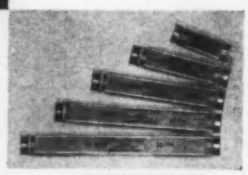
New POWER RESISTORS for FLIGHT USE

ELECTRO-FLEX

specialists in HEATING ELEMENTS

LESS SPACE—LESS WEIGHT

New lightweight, space-saving resistors permit substantial efficiencies and economies in aircraft and missile electronic apparatus. Units are mounted in direct contact with inner surface of chassis or case so that 25% to 40% of heat generated is emitted to atmosphere. Derating curves are available.



Available in the following ratings and sizes

Power Rating	Envelope Dimensions	Approx. Weight
40 Watts	7/32 x 1 5/16 x 4	.027 lbs. ea.
80 Watts	7/32 x 1 5/16 x 6	.040 lbs. ea.
120 Watts	7/32 x 1 5/16 x 8	.053 lbs. ea.
160 Watts	7/32 x 1 5/16 x 10	.067 lbs. ea.
200 Watts	7/32 x 1 5/16 x 12	.080 lbs. ea.

Insulation is silicone rubber—operable continuously at 450° F.
Mounting metal—Alclad aluminum.
Connection tabs—silver plated brass.

Special washers permit bolt or rivet mounting. Adhesive supplied provides good thermal transfer from resistor to mounting wall.

send for free illustrated booklet

Electro-Flex Heat, INC.
83 WOODBINE ST., HARTFORD, CONN. (CHapel 6-5413)

"FIRST with STANDARD ELEMENTS"

Circle 527 on Page 19

FREE 416-PAGE CATALOG

Lists over 8,000 Precision Instrument Parts and Components FROM STOCK

Featuring the NEW Precision Standard

PIC "Ultra-Precision"—Exceeds established standards, to provide the greater accuracy demanded by today's design, for the products of tomorrow.

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Contains 14 Actual Size Templates

A completely new design template system, created by working engineers, to assist you in the design and development of your specific mechanical systems.
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PIC DESIGN CORP.
Subsidiary of **BENRUS WATCH COMPANY, Inc.**
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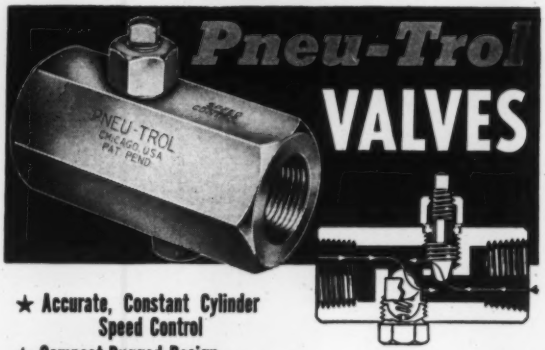


VALVES

★ **Accurate, Constant Cylinder Speed Control**
★ **Compact Rugged Design**
★ **Simple, Easy Speed Selection** ★ **For Air, Oil or Water Applications**

Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

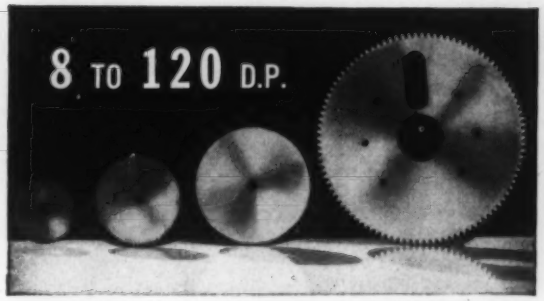
Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

Write for illustrated circular and prices.

PNEU-TROL, INC.
A DIVISION OF **AUTO-PONENTS, INC.**
2925 W. Grant Street • Bellwood, (Chicago Suburb) Illinois

Circle 528 on Page 19

Circle 529 on Page 19



LONG LIST OF STOCK GEAR DIES OFFERS YOU BIG SAVINGS!

ACCURATE STAMPED GEARS by *WINZELER* are BIG savers of time and money. Single stampings are laminated to wide faces at savings up to 60%! Further economies are made possible by a BIG range of *stock* Dies. Modern new plant, methods, and equipment now greatly increase production speed, efficiency and *economy!* Send blue prints. Tell us about your needs today. No obligation.

SEND FOR...

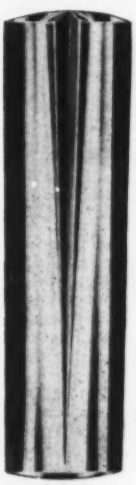
New list of WINZELER-made stock Gear Dies. Ask for it on company letterhead, *please!*

WINZELER *Stamped Gears*

WINZELER MANUFACTURING & TOOL CO.
7355 W. WILSON AVENUE • CHICAGO 31, ILLINOIS

Circle 530 on Page 19

need DRIV-LOK grooved pins in SPECIAL MATERIALS?



- aluminum
- alloy steel-heat treated
- brass
- stainless-303 and 416
- bronze

DRIV-LOK Pins — the positive locking, solid steel body grooved fasteners — are also available in a variety of special materials to meet particular requirements of strength, corrosion resistance, electrical qualities, or combinations of these properties. Like all DRIV-LOK Pins, they are carefully made to exacting standards, are easy to install and will reduce your fastening and assembly costs.

Write us, describing your fastening requirements. Recommendations made and catalog sent without obligation.

DRIV-LOK SALES CORPORATION
715 Park Avenue • Sycamore, Illinois

Circle 531 on Page 19

AUTOMATIC PRESSURE or VACUUM CONTROL J6

UE TYPE J6 PRESSURE & VACUUM CONTROL

UNITED ELECTRIC TYPE J6 unit is designed to automatically control either pressure or vacuum . . . has a fixed, uniform on-off differential as specified between limits of 3" WC to 2 PSI . . . and a maximum controlling pressure of 180 PSI. It is a sensitive, weatherproof, precision built control with good repeatability. Recommended for all pressure or vacuum applications which require close on-off differential control.

Switch Differential	Fixed as specified between limits of 3" WC to 2 PSI.
Switch Ratings	15 or 20 amps at 115 or 230 volts AC, also DC switches upon specification.
Switch Types	N.O., N.C., or Double Throw, no neutral position.
Size	$4\frac{3}{4}$" x $4\frac{27}{32}$" x $2\frac{5}{16}$".
Weight	Approx. 1 lb. 8 oz.
Electrical Connection	$\frac{1}{2}$" NPT conduit opening in enclosure, screw type terminals on switch is standard.
Enclosure	Die-cast aluminum case, black wrinkle finish standard.
Mounting	Surface mounted—by 2 mounting ears.
Bellows	Seamless brass—spring loaded.
Pressure Connection	$\frac{1}{4}$" NPT female connection.

UNITED ELECTRIC ***manufactures a complete line of temperature, pressure and vacuum controls. UE will gladly modify or custom-build a unit to your specifications. Consult a UE application engineer today.***

Write for Bulletin No. 5-3 for complete J6 data.

United Electric Controls
COMPANY
SCHOOL STREET WATERTOWN MASS.

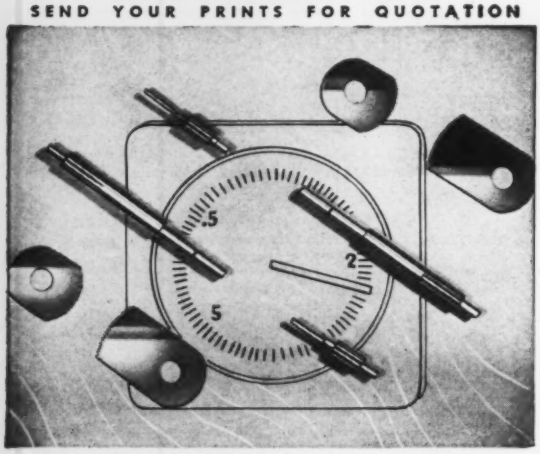
Circle 532 on Page 19

THE TREND IN DRAFTING ROOMS THROUGHOUT THE WORLD IS TOWARD IMPERIAL, THE WORLD'S FINEST TRACING CLOTH

Circle 533 on Page 19

20 TO 200 D.P.

SEND YOUR PRINTS FOR QUOTATION



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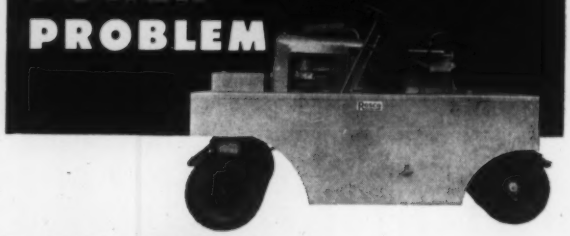
STRAIGHT BEVELS • LEAD SCREWS • RATCHETS
CLUSTER GEARS • RACKS • INTERNALS • ODD SHAPES

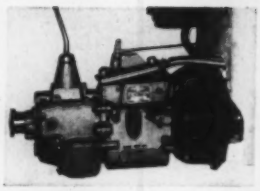
THE *Finest* IN GEARS

Beaver Gear Works Inc.

1031 PARMELE ST. ROCKFORD, ILLINOIS

FUNK FOUND THE ANSWER TO THIS POWER PROBLEM





On this Rosco Road Roller, a FUNK-designed Revers-O-Matic Drive permits triple operation with just one foot lever. Instantly and smoothly changes the speed and direction of travel — without wheel spinning, provides neutral speed control and leaves hands free for other operations.

Just one example of how FUNK MODULAR POWER UNITS may be combined in an unlimited number of arrangements — without special engineering costs.

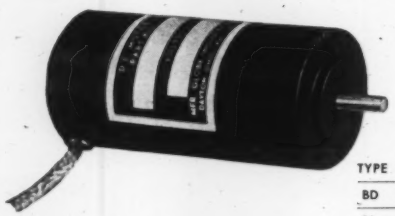
Let FUNK help solve your power transmission problem.

FUNK MFG. CO. P. O. Box 577-E COFFEYVILLE, KANSAS

Circle 534 on Page 19

NEW D.C. MOTORS

precision / high torque



TYPE	O.D.	LENGTH
BD	1½"	2¾"
BL	1½"	2 15/16"

Here are two new Globe precision PM d.c. motors which offer unusually high output for package size. In nominal ratings to 1/30 hp., a complete range of standard windings are available, plus special windings as necessary, allowing the designer a wide choice of performance characteristics. Type BD and BA motors are designed to meet MIL-M-8609 and MIL-E-5272 for performance and environment requirements.

Typical output with a 26 v. winding is 4 oz. in. at 10,000 rpm. Speed governors may be made a part of the package for constant speed in the range of 5,000 to 12,000 rpm. Planetary gear reducers may be incorporated, offering over 100 standard ratios, as well as special ratios. Maximum weight is 11¼ oz. Special modifications welcomed. Fast prototypes. Request Bulletin 112.

GLOBE

Globe Industries, Inc.
1784 Stanley Avenue, Dayton 4, Ohio
Telephone BAldwin 2-3741

Circle 535 on Page 19

Circle 536 on Page 19

automatic
drag brake

for intermittent use

Do you have the problem of putting constant or variable tension on material in process—or a compensating drag load on shafts or spindles? A Warner electric brake will produce intermittent slippage and perform these functions automatically. The electromagnetic principle solves any problem of actuation, and a simple potentiometer control permits you to modulate torque output steplessly for producing exactly the right slippage for any job. Write for Catalog No. 6292.

WARNER **Warner Electric Brake & Clutch Co.**
Beloit, Wisconsin

Circle 537 on Page 19

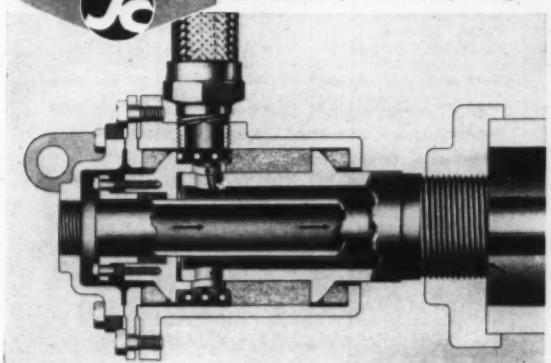
STANDS ALONE!

Type SN Johnson ROTARY PRESSURE Joint

There's not another rotary joint like the Johnson Type SN. Used where inlet or outlet pipe must rotate with the roll—on certain paper machines, drilled rolls of rubber or plastic mills and calenders, double shell dryers, and the like. Needs no external supports of any kind. Like all Johnson Joints the Type SN seals without packing, needs no lubrication or adjustment.

Investigate Johnson Joints for all steam-heated or water-cooled rolls. Handle Dowtherm, Monsanto Aroclors, hot oils too. Sizes to 8". For data on Type SN write for Bulletin N-2002.

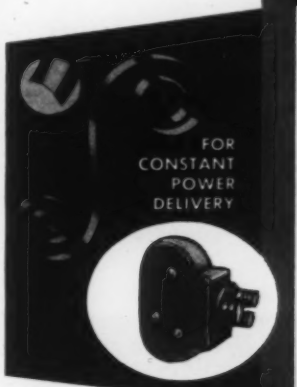
THE JOHNSON CORPORATION
811 Wood St., Three Rivers, Michigan



Circle 538 on Page 19

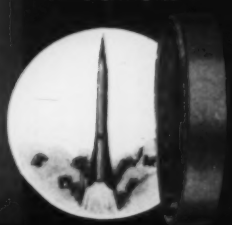
Which Kind of SANDVIK SPRING PERFORMANCE Fits YOUR Product?

Sandvik SPIRAL springs provide long-lived, low-cost service for starters, guard return springs, toys or tension devices where constant torque is not critical.



Sandvik CROSS-CURVED springs have a dual tension produced by winding the spring against both its tempered spiral and against a special convex curvature across the width of the strip. The longer, more even energy release provides uniform power for timing instruments, carriage return springs, movie cameras and other high performance applications.

Sandvik 2R25 stainless springs are a super quality which give 5 to 10 times longer performance than ordinary carbon steel springs and can take the corrosive attacks of varying atmospheres too. For applications where performance demand outranks cost, such as in missiles, aircraft and special instruments.



These examples give you some idea of Sandvik's ability to supply the spring that fits your application in both performance and cost. You can draw on Sandvik's fund of over 30 years of spring experience to help select or develop the exact size and type that's right for your product. Ask for further information or send us the data on your spring application.

SANDVIK STEEL, INC.
Fair Lawn, New Jersey
Tel. SWarthmore 7-6200
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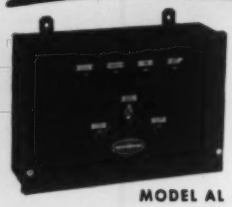
Circle 539 on Page 19

MADE FOR . . .
YOUR ENGINE'S
Protection



MODEL AL

Any abnormal condition existing in your engine can be immediately brought under control by the operator with the use of Synchro-Start . . . . . .

AUTOMATIC ENGINE CONTROLS

Your engine can be protected by being automatically shut down at the first sign of low oil pressure, high water temperature, overspeed, etc.

The AL series of Synchro-Start Controls is made to fit individual requirements. Your specifications sent to us will bring immediate response.

Write for detailed information

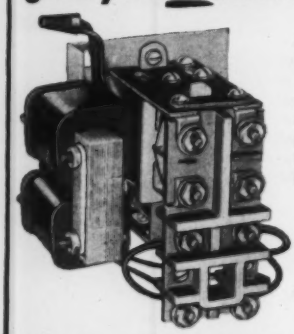
SYNCHRO-START PRODUCTS, INC.

Since 1932

8151 NORTH RIDGEWAY AVENUE • SKOKIE, ILLINOIS

Circle 540 on Page 19

WARRICK Floatless Electrode Type
LIQUID LEVEL CONTROLS . . .
give you all these advantages!



No moving parts in the liquid • Easy to install • No adjustments necessary • Unaffected by acids or caustics • Unaffected by pressure or temperature • Standard 2&3 pole units listed by U/L

Write for 32-page Catalog which gives complete specifications

Two pole control shown at left

YOU CAN USE OUR CONTROLS FOR:

- Single & multiple pumps
- Motor & solenoid valves
- High & low cutoffs & alarms
- Sewage & waterworks
- Chemical Industries
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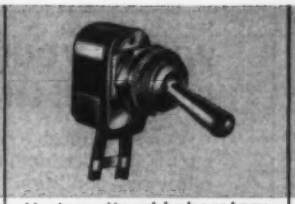
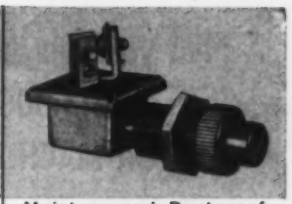


Underwriters' Laboratory Approved Toggle Switches With or Without Wire Leads.

Complete Electrical Control Switch Panel for Electric Starting Requirements.



Moisture and Dustproof Momentary Starter or Choke Switch.

COLE-HERSEE

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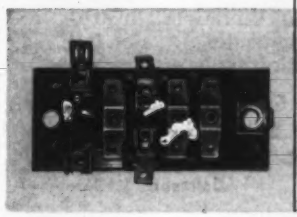
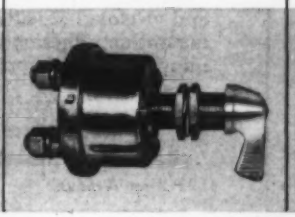
Over 40 Years of Consistently Better Products
20 OLD COLONY AVENUE, BOSTON 27, MASS.

Quality ELECTRICAL PRODUCTS

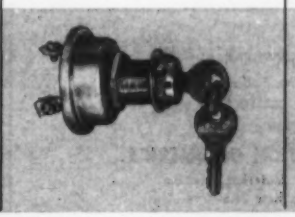
Terminal and Fuse Blocks With Fast Slip-On Type Terminals.



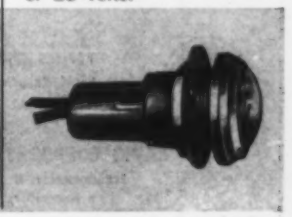
Battery Master Disconnect Switches. Single and Double-Pole Versions.



Combination Ignition Starter Switches With Coded Tumbler Lock and Keys.



Pilot Lamps — Gasketed, Waterproof With Clear or Red Faceted Lenses. Single or Double Contact. 6, 12 or 28 volts.



Circle 542 on Page 19

Sicon®

HEAT RESISTANT FINISH

PROTECTS ENGINE SHROUDS OF THE

MARTIN MATADOR

When USAF TM-61 Martin Matadors are recalled for servicing and refinishing, SICON Silicone finish is specified because it meets the performance required.

Sicon's ability to withstand high temperatures up to 1000°F. without breakdown has won an enviable name for itself in the aircraft industry, as well as in many others.

Write for new SICON Bulletin—Dept. No. M-9.

MIDLAND
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ALLEN AIR CORP. DOUBLES PRODUCTION*

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Circle 547 on Page 19

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Advertising Index

Acheson Colloids Co., A Division of Acheson Industries, Inc. 50
Acme Chain Corporation 149
Acushnet Process Co. 178
Adams & Westlake 150
A'G'A Division, Elastic Stop Nut Corporation of America 178
Airborne Accessories Corporation 158
Allegheny Ludlum Steel Corporation 91
AllenAir Corporation 185
American Brass Co., The 5
American Nickeloid Co. 152
American Sealants Co. 170
American Smelting and Refining Co. 89
American-Standard, Industrial Division 41
American Steel & Wire Division, United States Steel Corporation 64, 65
American Welding & Mfg. Co., The 90
Automotive Gear Division, Eaton Manufacturing Co. 16
Auto-Ponents, Inc., Pneu-Trol Division 180

Babcock & Wilcox Co., The Tubular Products Division 190
Baldor Electric Co. 143
Barco Manufacturing Co. 179
Barden Corporation, The 173
Barksdale Valves, Control Valve Division 174
Battelle Memorial Institute 186
Beaver Gear Works, Inc. 182
Bethlehem Steel Co. 93
Blood Brothers Universal Joints Division, Rockwell-Standard Corporation 139
Borg-Warner Corporation, Rockford Clutch Division 172
Boston Gear Works 29
Briggs Filtration Co., The 160
Brush Instruments Division of Clevite Corporation 84
Buffalo Bolt Co., Division of Buffalo-Eclipse Corporation 155
Buffalo-Eclipse Corporation, Buffalo Bolt Co. Division 155
Bunting Brass and Bronze Co., The 159

Carpenter Steel Co., The, Alloy Tube Division. 21
Celanese Corporation of America, Chemical Division 33
Central Foundry Division, General Motors Corporation 72, 73
Clearprint Paper Co. 76
Cleveland Worm and Gear Co., The ..... Inside Back Cover
Clevite Corporation, Brush Instruments Division 84
Cole-Hersee Co. 185
Columbia-Geneva Steel Division, United States Steel Corporation 64, 65
Consolidated Molded Products Corporation ... 145
Copperweld Steel Co., Ohio Seamless Tube Division 67
Crane Packing Co. 27
Crucible Steel Company of America 54, 55
Cutler-Hammer, Inc. ..... Back Cover

Diamond Chain Co., Inc. 80
Dixon Corporation 151
Driv-Lok Sales Corporation 181
Du Pont, E. I., de Nemours & Co., Inc. 57, 58
Durez Plastics Division, Hooker Chemical Corporation 83

Eastern Industries, Inc. ..... Inside Front Cover
Eaton Manufacturing Co., Automotive Gear Division 16
Elastic Stop Nut Corporation of America, A'G'A Division 178
Electro-Flex Heat, Inc. 180
Erie Ceramic Arts Co., The 30

Fischer Special Mfg. Co. 35
Funk Mfg. Co. 182

Garlock Packing Co., The 47
Gates Rubber Co., The 87
General Aniline & Film Corporation, Ozalid Division 44
General Motors Corporation, Central Foundry Division 72, 73
General Motors Corporation, New Departure Division 11
Globe Industries, Inc. 182
Goodrich, B. F., Co., The, Aviation Products Division 81
Goodyear Tire & Rubber Co., The, Industrial Products Division 37, 38, 39, 40
Gould-National Batteries, Inc., Nicad Division 153
Gries Reproducer Corporation 160
Grip Nut Co. 150
Groov-Pin Corporation 66

Hanna Engineering Works 61
Harrington & King Perforating Co., Inc., The. 168
Hartford Steel Ball Co., Inc. 179
Haydon, A. W., Co. 144
Heim Co., The 88
Hetherington, Inc. 147
Hooker Chemical Corporation, Durez Plastics Division 83
Houdaille Industries, Inc., Manzel Division .. 178

Imperial Pencil Tracing Cloth Co. 182
Industrial Timer Corporation 92
International Basic Economy Corporation, Valvair Division 141

Johns-Manville 52
Johnson, Carlyle, Machine Co., The 142
Johnson Corporation, The 183

Keuffel & Esser Co. 136

Lamson & Sessions 94
Leiman Bros., Inc. 176
Link-Belt Co. 75
Lord Manufacturing Co. 51
Lovejoy Flexible Coupling Co. 154

McGill Manufacturing Co., Inc. 68

Mac-It Parts Co. 26
Malleable Castings Council 78, 79
Mallory-Sharon Metals Corporation 74
Manzel, A Division of Houdaille Industries, Inc. 178
Marlin-Rockwell Corporation 70
Mayline Co., Inc. 178
Mead Specialties Co. 82
Midland Industrial Finishes Co. 185
Milford Rivet & Machine Co., The 148
Molded Fiber Glass Body Co. 36
Moore, George W., Inc. 177
Mt. Vernon Die Casting Corporation 69

New Departure Division of General Motors Corporation 11
Nicad Division, Gould-National Batteries, Inc. 153

Ohio Seamless Tube Division of Copperweld Steel Co. 67
Ohmite Manufacturing Co. 71
Oilgear Co., The 7
O'Neil-Irwin Mfg. Co. 170
Ortman-Miller Machine Co. 154
Ozalid, A Division of General Aniline & Film Corporation 44

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Pneu-Trol, Inc., A Division of Auto-Ponents, Inc. 180
Post, Frederick, Co. 15
Potter & Brumfield, Inc. 31

Rae Motor Corporation 180
Radio Corporation of America, Semiconductor & Materials Division 186
Robbins & Myers, Inc. 48, 49
Rockford Clutch Division, Borg-Warner Corporation 172
Rockwell-Standard Corporation, Blood Brothers Universal Joints Division 139
Rockwell-Standard Corporation, Transmission and Axle Division 59
Ross Operating Valve Co. 1
Rucqual, Leon G., & Associates, Inc. 186
Ruthman Machinery Co., The 157

Sandvik Steel, Inc. 183
Sewall, E. B., Manufacturing Co. 162
Simplatrol Products Corporation 179
Skinner Electric Valve Division, The 53
Southwest Products Co. 177
S-P Manufacturing Corporation, The 34
Spectrol Electronics Corporation 164
Spherco, Sealmaster Bearing Division, Stephens-Adamson Mfg. Co. 164
Square D Co. 42, 43
Stackpole Carbon Co. 156
Standard Pressed Steel Co., Unbrako Socket Screw Division 77
Stanpat Co. 158
Steinen, Wm., Mfg. Co., Industrial Nozzle Division 177
Stephens-Adamson Mfg. Co., Spherco, Sealmaster Bearing Division 164
Struthers-Dunn, Inc. 163
Synchro-Start Products, Inc. 184

Tennessee Coal & Iron Division, United States Steel Corporation 64, 65
Thomson Industries, Inc. 161
Timken Roller Bearing Co., The, Steel and Tube Division 2
Tomkins-Johnson Co., The 85
Torrington Co., The 13
Torrington Manufacturing Co., The 63
Transmission and Axle Division, Rockwell-Standard Corporation 59
Twin Disc Clutch Co. 9

Union Chain and Manufacturing Co., The 166
United Electric Controls Co. 181
United States Graphite Co., The, Division of The Wickes Corporation 46
United States Steel Corporation, Subsidiaries 64, 65
United States Steel Export Co. 64, 65

Valvair Corporation, Division of International Basic Economy Corporation 141
Viking Pump Co. 144
Vlier Engineering Corporation 86
Vulcan Electric Co. 148

Wagner Electric Corporation 60
Waldron, John, Corporation 56
Warner Electric Brake & Clutch Co. 183
Warrick, Charles F., Co. 184
Washington Steel Corporation 167
White, S. S., Industrial Division 62
Whitney Chain Co. 169
Wickes Corporation, The, The United States Graphite Co. Division 46
Winzeler Manufacturing & Tool Co. 181
Wood's, T. B., Sons Co. 165
Wyman-Gordon Co. 45

Engineers Available or Wanted 186

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A PANEL—Manufacturing Engineering—IBM, Endicott, N. Y.
1. ORGANIZATION—**KEITH BENNETT,** Project Engr., Test Equipment Engineering
2. STUDY OF OPERATIONS—**GEORGE PHILLIP,** Project Engr., Mfg. Research
3. DEVELOPING THE HARDWARE—**ALFRED JOHNSON,** Project Engr., Mfg. Research
4. DATA PROCESSING—**WILLIAM ANDRUS,** Manager of Applied Computation
5. ECONOMICS—**RICHARD SEILER,** Technical Ass't to Ass't Mfg. Engr.

Buffet Lunch — **Pioneering in Automation**

WILLIAM ALDEN, President, Automation Management Inc.

Industrial Engineering's Role in Automation of Operations

H. H. YOUNG, Assoc. Prof., Dept of Industrial Engineering, Purdue University

Cost Analysis and Machine Replacement

ROBERT A. LOWE, Managing Partner, R. A. Lowe & Co.

TUESDAY . . . . . SESSION III & IV . . . . . MARCH 24, 1959

Manufacturing Engineering and Machine Procurement

ARMIN FRANK, Manager-Manufacturing, Vacuum Cleaner Dept., General Electric Co.

Assembling Complex Devices

GEORGE WEISER, Chief Process Engineer, Delco-Remy Div., General Motors Corp.

Buffet Lunch — **Automation on the Farm**

E. W. LEHMANN, Prof. Emeritus, Agricultural Engineering, University of Illinois

Handling as the Key to Automation for the Small Company

JAMES R. SEBASTIAN, President, The Rapids-Standard Co. Inc.

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Banquet — **Guaranteed Annual Automation**

LEON GREENBERG, Chief, Div. of Productivity, U. S. Dept. of Labor

WEDNESDAY . . . . SESSION V & VI . . . . MARCH 25, 1959

Modern Developments in Control

DR. JOSEPH F. MANILDI, General Manager, Thompson-Ramo-Wooldridge Products Co.

Numerical Control of Production Machines

W. E. BRAINARD, Chief Engineer, Servo Machine Tool Div., Kearney & Trecker Corp.

Buffet Lunch — **Automating the Horses**

O. C. LEVY, Vice President, American Totalisator Co., Div. of Universal Control Inc.

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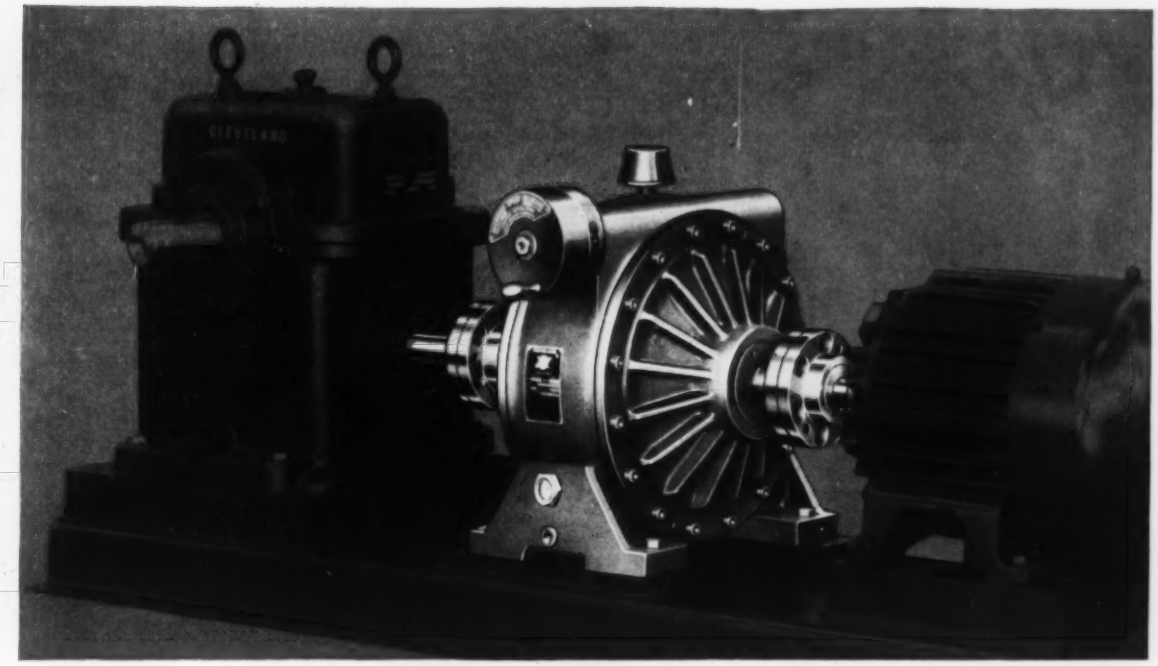

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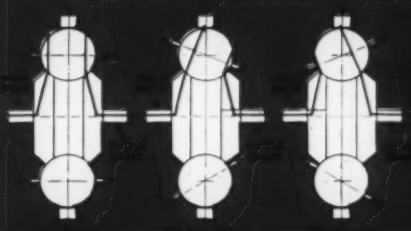

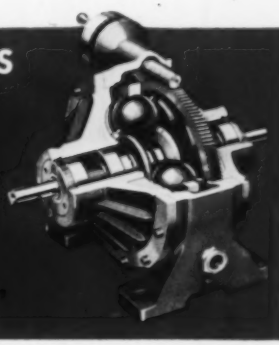

Circle 402 on Page 19

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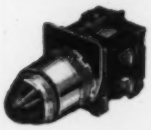

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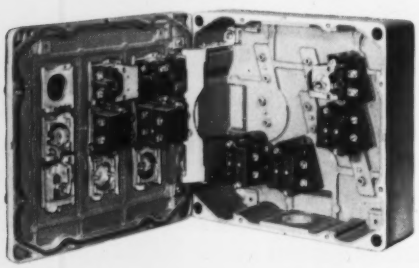

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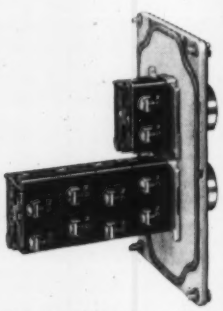

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Circle 403 on Page 19